FLORIDA FIRST PROCESSING L.P.

Protecting Florida's Environmental Future

RCRA Part B & Air Permit Application

Volume I

NOTICE(S):

(1) As of October, 1990 ownership in Florida First Processing, Inc. (FFPI) has been transferred to Florida First Processing, Limited Partnership (FFP-LP). Thus, any and all references to Florida First Processing, Inc. in previous revisions or copies of the permit application, engineering drawings or NOD responses should be considered to refer to Florida First Processing, L.P. (FFP-LP).

(2) The Florida First Processing, Inc. application referred to FAC 17-30 in previous submittals. Due to the fact that FAC 17-730 has superseded FAC 17-30, all previous references to FAC 17-30 should be viewed as referring to FAC 17-730.

(3) Questions or comments on the RCRA Part B and air permit application and NOD responses should be directed to Tony Moscati, FFP-LP, 8150 Leesburg Pike, Suite 700, Vienna, Virginia 22182; (703) 883-8270.

(4) All previous references to EP-TOX are now to be considered as referring to Toxicity Characteristic Leaching Procedure ("TCLP") due to changes in regulations since the date of the original submittal of the RCRA Part B and Air Permit applications.

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L. AIR PERMIT APPLICATION (Continued)

APPLICATION FOR A HAZARDOUS WASTE FACILITY PERMIT

PART I - GENERAL

TO BE COMPLETED BY ALL APPLICANTS

(Please Type or Print)

A. GENERAL INFORMATION

1. TYPE OF FACILITY:
   Disposal [ ]
   Landfill [ ]   Land Treatment [ ]   Surface Impoundment [ ]

   Storage [X]
   Containers [X]   Tanks [X]   Piles [ ]   Surface Impoundment [ ]

   TREATMENT [X]
   Tanks [X]   Piles [ ]   Incineration [X]   Surface Impoundment [ ]
   Thermal [ ]   Chemical [X]   Physical [ ]   Biological [ ]

2. TYPE OF APPLICATION: [ ]Top [X]Construction [ ]Operation [ ]Closure [ ]RD&D

3. DATE CURRENT OPERATION BEGAN (OR IS EXPECTED TO BEGIN): Spring/Summer 1991

4. FACILITY NAME: Florida First Processing, L.P.

5. EPA/DER I.D. NO.: FLD 982 134 355

6. FACILITY LOCATION OR STREET ADDRESS: West side of Fort Green Rd, 3/4 mi. south of County Road 630, Polk County, Florida.

7. FACILITY MAILING ADDRESS: FFP-LP, 8150 Leesburg Pike, Suite 700, Vienna, Virginia 22182

8. CONTACT PERSON: Dr. A.F. Moscati, Jr.   TELEPHONE: (703) 883-8270
   TITLE: Managing Director
   MAILING ADDRESS: 8150 Leesburg Pike, Suite 700 (Street or P.O. Box)   Vienna (City)   VA (State)   22182 (Zip)

9. OPERATOR'S NAME: Florida First Processing, L.P.   TELEPHONE: (703) 883-8270

10. OPERATOR'S ADDRESS: 8150 Leesburg Pike, Suite 700 (Street or P.O. Box)   Vienna (City)   VA (State)   22182 (Zip)

11. FACILITY OWNERS'S NAME: Florida First Processing, L.P.

12. FACILITY OWNER'S ADDRESS: 8150 Leesburg Pike, Suite 700, Vienna, VA (Street or P.O. Box / City / State)   22182 (Zip)

13. LEGAL STRUCTURE: [ ] Corporation   [ ] Non-Profit Corporation   [X] Partnership
    [ ] Individual   [ ] Local Government   [ ] State Government   [ ] Federal Government
    Other ______

14. IF AN INDIVIDUAL, PARTNERSHIP, OR BUSINESS IS PERFORMED UNDER AN ASSUMED NAME, SPECIFY COUNTY AND STATE WHERE NAME IS REGISTERED. COUNTY: N/A   STATE: N/A

15. IF A CORPORATION, INDICATE STATE OF INCORPORATION: ______

16. IF AN INDIVIDUAL OR PARTNERSHIP, LIST OWNERS:

NAME: ICF Florida First, Inc.

ADDRESS 9300 Lee Highway — Fairfax — VA — 22031-1207
STREET OR P.O. BOX — CITY — STATE — ZIP

NAME: First City Florida First, Inc.

ADDRESS 499 Park Avenue — New York — NY — 10022
STREET OR P.O. BOX — CITY — STATE — ZIP

NAME: LMH, Inc.

ADDRESS: 8150 Leesburg Pike, Suite 700 — Vienna — VA — 22182
STREET OR P.O. BOX — CITY — STATE — ZIP

17. SITE OWNERSHIP STATUS [X] OWNED [ ] TO BE PURCHASED [ ] TO BE LEASED ______ YEARS
[ ] PRESENTLY LEASED: EXPIRATION DATE ____________ IF LEASED, GIVE:
LANDOWNER'S NAME ______________________________
LANDOWNER'S ADDRESS ______________________________
STREET OR P.O. BOX — CITY — STATE — ZIP

18. ENGINEER: Dick M. Miller — REGISTRATION NO.: 20927 (Florida)

ADDRESS: Robinson Plaza II, Suite 200, Pittsburgh, — PA — 15205
STREET OR P.O. BOX — CITY — STATE — ZIP

ASSOCIATED WITH: International Waste Energy Systems

19. FACILITY LOCATED ON INDIAN LAND: [ ] YES [X] NO

20. EXISTING OR PENDING ENVIRONMENTAL PERMITS: (ATTACH A SEPARATE SHEET IF NECESSARY)

NAME OF PERMIT	AGENCY	PERMIT NUMBER	DATE ISSUED	EXPIRATION DATE

PROCESS CODE	PROCESS DESIGN CAPACITY AND UNITS OF MEASURE	HAZARDOUS WASTE CODE	ANNUAL QUANTITY OF HAZARDOUS WASTE AND UNITS OF MEASURE
S01	413,600 G		16,112,923 G
		D001	included with above
		D002	included with above
		D003	included with above
		D004	included with above
		D005	included with above
		D006	included with above
		D007	included with above
		D008	included with above
		D009	included with above
		D010	included with above
		D011	included with above
		D012	included with above
		D013	included with above
		D014	included with above
		D015	included with above
		D016	included with above
		D017	included with above
		D018	included with above
		D019	included with above
		D020	included with above
		D021	included with above
		D022	included with above
		D023	included with above
		D024	included with above
		D025	included with above
		D026	included with above
		D027	included with above
		D028	included with above
		D029	included with above
		D030	included with above
		D031	included with above
		D032	included with above
		D033	included with above
		D034	included with above
		D035	included with above
		D036	included with above
		D037	included with above
		D038	included with above
		D039	included with above
		D040	included with above
		D041	included with above
		D042	included with above
		D043	included with above
		F001	included with above
		F002	included with above
		F003	included with above
		F004	included with above
		F005	included with above
		F006	included with above

PROCESS CODE	PROCESS DESIGN CAPACITY AND UNITS OF MEASURE	HAZARDOUS WASTE CODE	ANNUAL QUANTITY OF HAZARDOUS WASTE AND UNITS OF MEASURE
		F007	included with above
		F008	included with above
		F009	included with above
		F010	included with above
		F011	included with above
		F012	included with above
		F019	included with above
		F024	included with above
		F025	included with above
		~~F032*~~	~~included with above~~
		~~F033*~~	~~included with above~~
		F034	included with above
		F035	included with above
		F039	included with above
		K001	included with above
		K002	included with above
		K003	included with above
		K004	included with above
		K005	included with above
		K006	included with above
		K007	included with above
		K008	included with above

PROCESS CODE	PROCESS DESIGN CAPACITY AND UNITS OF MEASURE	HAZARDOUS WASTE CODE	ANNUAL QUANTITY OF HAZARDOUS WASTE AND UNITS OF MEASURE
S01 (cont.)		U238	included with above
		U239	included with above
		U240	included with above
		U243	included with above
		U244	included with above
		U246	included with above
		U247	included with above
		U248	included with above
		U249	included with above
		U328	included with above
		U353	included with above
		U359	included with above
S02	727,475G		16,112,923 G
		D001	included with above
		D002	included with above
		D003	included with above
		D004	included with above
		D005	included with above
		D006	included with above
		D007	included with above
		D008	included with above
		D009	included with above
		D010	included with above
		D011	included with above
		D012	included with above
		D013	included with above
		D014	included with above
		D015	included with above
		D016	included with above
		D017	included with above
		D018	included with above
		D019	included with above
		D020	included with above
		D021	included with above
		D022	included with above
		D023	included with above
		D024	included with above
		D025	included with above
		D026	included with above
		D027	included with above
		D028	included with above
		D029	included with above
		D030	included with above
		D031	included with above
		D032	included with above
		D033	included with above
		D034	included with above

PROCESS CODE	PROCESS DESIGN CAPACITY AND UNITS OF MEASURE	HAZARDOUS WASTE CODE	ANNUAL QUANTITY OF HAZARDOUS WASTE AND UNITS OF MEASURE
		D035	included with above
		D036	included with above
		D037	included with above
		D038	included with above
		D039	included with above
		D040	included with above
		D041	included with above
		D042	included with above
		D043	included with above
		F001	included with above
		F002	included with above
		F003	included with above
		F004	included with above
		F005	included with above
		F006	included with above
		F007	included with above
		F008	included with above
		F009	included with above
		F010	included with above
		F011	included with above
		F012	included with above
		F019	included with above
		F024	included with above

PROCESS CODE	PROCESS DESIGN CAPACITY AND UNITS OF MEASURE	HAZARDOUS WASTE CODE	ANNUAL QUANTITY OF HAZARDOUS WASTE AND UNITS OF MEASURE
S02 (cont.)		F025	included with above
		~~F032*~~	~~included with above~~
		~~F033*~~	~~included with above~~
		F034	included with above
		F035	included with above
		F039	included with above
		K001	included with above
		K002	included with above
		K003	included with above
		K004	included with above
		K005	included with above
		K006	included with above
		K007	included with above
		K008	included with above
		K009	included with above
		K010	included with above
		K011	included with above
		K013	included with above
		K014	included with above
		K015	included with above
		K016	included with above
		K017	included with above
		K018	included with above
		K019	included with above
		K020	included with above
		K021	included with above
		K022	included with above
		K023	included with above
		K024	included with above
		K025	included with above
		K026	included with above
		K027	included with above
		K028	included with above
		K029	included with above
		K030	included with above
		K031	included with above
		K032	included with above
		K033	included with above
		K034	included with above
		K035	included with above
		K036	included with above
		K037	included with above
		K038	included with above
		K039	included with above
		K040	included with above
		K041	included with above
		K042	included with above
		K043	included with above
		K048	included with above
		K049	included with above
		K050	included with above
		K051	included with above
		K052	included with above

PROCESS CODE	PROCESS DESIGN CAPACITY AND UNITS OF MEASURE	HAZARDOUS WASTE CODE	ANNUAL QUANTITY OF HAZARDOUS WASTE AND UNITS OF MEASURE
S02 (cont.)		K060	included with above
		K061	included with above
		K062	included with above
		K064	included with above
		K065	included with above
		K066	included with above
		K069	included with above
		K071	included with above
		K073	included with above
		K083	included with above
		K084	included with above
		K085	included with above
		K086	included with above
		K087	included with above
		K088	included with above
		K090	included with above
		K091	included with above
		K093	included with above
		K094	included with above
		K095	included with above
		K096	included with above
		K097	included with above
		K098	included with above
		K099	included with above
		K100	included with above
		K101	included with above
		K102	included with above
		K103	included with above
		K104	included with above
		K105	included with above
		K106	included with above
		K111	included with above
		K112	included with above
		K113	included with above
		K114	included with above
		K115	included with above
		K116	included with above
		K117	included with above
		K118	included with above
		K123	included with above
		K124	included with above
		K125	included with above
		K126	included with above
		K136	included with above
		P001	included with above
		P002	included with above
		P003	included with above
		P004	included with above
		P005	included with above
		P006	included with above
		P007	included with above

PROCESS CODE	PROCESS DESIGN CAPACITY AND UNITS OF MEASURE	HAZARDOUS WASTE CODE	ANNUAL QUANTITY OF HAZARDOUS WASTE AND UNITS OF MEASURE
SO2 (cont.)		U220	included with above
		U221	included with above
		U222	included with above
		U223	included with above
		U225	included with above
		U226	included with above
		U227	included with above
		U228	included with above
		U234	included with above
		U235	included with above
		U236	included with above
		U237	included with above
		U238	included with above
		U239	included with above
		U240	included with above
		U243	included with above
		U244	included with above
		U246	included with above
		U247	included with above
		U248	included with above
		U249	included with above
		U328	included with above
		U353	included with above
		U359	included with above
TO1	43,800G		9,264,400G
		D002	included with above
		D003	included with above
		D004	included with above
		D005	included with above
		D006	included with above
		D007	included with above

PROCESS CODE	PROCESS DESIGN CAPACITY AND UNITS OF MEASURE	HAZARDOUS WASTE CODE	ANNUAL QUANTITY OF HAZARDOUS WASTE AND UNITS OF MEASURE
		D008	included with above
		D009	included with above
		D010	included with above
		D011	included with above
		D012	included with above
		D013	included with above
		D014	included with above
		D015	included with above
		D016	included with above
		D017	included with above
		D018	included with above
		D019	included with above
		D020	included with above
		D021	included with above
		D022	included with above
		D023	included with above
		D024	included with above
		D025	included with above
		D026	included with above
		D027	included with above
		D028	included with above
		D029	included with above
		D030	included with above
		D031	included with above
		D032	included with above
		D033	included with above
		D034	included with above
		D035	included with above
		D036	included with above
		D037	included with above
		D038	included with above
		D039	included with above
		D040	included with above
		D041	included with above
		D042	included with above
		D043	included with above
		F001	included with above
		F002	included with above
		F006	included with above
		F007	included with above
		F008	included with above
		F009	included with above
		F010	included with above
		F011	included with above
		F012	included with above
		F019	included with above

PROCESS CODE	PROCESS DESIGN CAPACITY AND UNITS OF MEASURE	HAZARDOUS WASTE CODE	ANNUAL QUANTITY OF HAZARDOUS WASTE AND UNITS OF MEASURE
T01 (cont.)		F024	included with above
		F025	included with above
		~~F032*~~	~~included with above~~
		~~F033*~~	~~included with above~~
		F034	included with above
		F035	included with above
		F039	included with above
		K001	included with above
		K002	*included with above*
		K003	included with above
		K004	included with above
		K005	included with above
		K006	included with above
		K007	included with above
		K008	included with above
		K021	included with above
		K028	included with above
		K031	included with above
		K032	included with above
		K033	included with above
		K034	included with above
		K035	included with above
		K036	included with above
		K037	included with above
		K038	included with above
		K039	included with above
		K040	included with above
		K041	included with above
		K042	included with above
		K043	included with above
		K060	included with above
		K061	included with above
		K062	included with above
		K064	included with above
		K065	included with above
		K066	included with above
		K069	included with above
		K071	included with above
		K073	included with above
		K084	included with above
		K086	included with above
		K087	included with above
		K088	included with above
		K090	included with above
		K091	included with above
		K097	included with above

PROCESS CODE	PROCESS DESIGN CAPACITY AND UNITS OF MEASURE	HAZARDOUS WASTE CODE	ANNUAL QUANTITY OF HAZARDOUS WASTE AND UNITS OF MEASURE
T01 (cont.)		P059	included with above
		P060	included with above
		P062	included with above
		P063	included with above
		P064	included with above
		~~P065~~	~~included with above~~
		P066	included with above
		P070	included with above
		P071	included with above
		P072	included with above
		P074	included with above
		P075	included with above
		P076	included with above
		P078	included with above
		P087	included with above
		P088	included with above
		P089	included with above
		P092	included with above
		P094	included with above
		P095	included with above
		P096	included with above
		P097	included with above
		P098	included with above
		P099	included with above
		P101	included with above
		P104	included with above
		P105	included with above
		P106	included with above
		P108	included with above
		P109	included with above
		P111	included with above
		P113	included with above
		P114	included with above
		P115	included with above
		P118	included with above
		P119	included with above
		P120	included with above
		P121	included with above
		P122	included with above
		P123	included with above
		U005	included with above
		U006	included with above
		U008	included with above
		U009	included with above
		U011	included with above
		U017	included with above
		U020	included with above
		U023	included with above
		U024	included with above
		U025	included with above
		U026	included with above

PROCESS CODE	PROCESS DESIGN CAPACITY AND UNITS OF MEASURE	HAZARDOUS WASTE CODE	ANNUAL QUANTITY OF HAZARDOUS WASTE AND UNITS OF MEASURE
TO1 (cont.)		U112	included with above
		U113	included with above
		U114	included with above
		U115	included with above
		U118	included with above
		U119	included with above
		U121	included with above
		U122	included with above
		U123	included with above
		U125	included with above
		U127	included with above
		U128	included with above
		U129	included with above
		U130	included with above
		U131	included with above
		U132	included with above
		U134	included with above
		U135	included with above
		U136	included with above
		U142	included with above
		U143	included with above
		U144	included with above
		U145	included with above
		U150	included with above
		U151	included with above
		U156	included with above
		U158	included with above
		U162	included with above
		U165	included with above
		U178	included with above
		U183	included with above
		U184	included with above
		U185	included with above
		U189	included with above
		U191	included with above
		U192	included with above
		U200	included with above
		~~U202~~	~~included with above~~
		U202	included with above
		U204	included with above
		U205	included with above
		U207	included with above
		U208	included with above
		U209	included with above
		U210	included with above
		U211	included with above
		U214	included with above
		U215	included with above
		U216	included with above
		U217	included with above
		U222	included with above

Date: 10/15/90
Revision: 1

PROCESS CODE	PROCESS DESIGN CAPACITY AND UNITS OF MEASURE	HAZARDOUS WASTE CODE	ANNUAL QUANTITY OF HAZARDOUS WASTE AND UNITS OF MEASURE
TO1 (cont.)		U223	included with above
		U225	included with above
		U226	included with above
		U227	included with above
		U228	included with above
		U235	included with above
		U236	included with above
		U237	included with above
		U238	included with above
		U240	included with above
		U243	included with above
		U244	included with above
		U246	included with above
		U247	included with above
		U248	included with above
		U249	included with above
		U328	included with above
		U353	included with above
		U359	included with above
TO3	5.6 D		40,000 T
		D001	included with above
		D003	included with above
		D012	included with above
		D013	included with above
		D014	included with above
		D015	included with above
		D016	included with above
		D017	included with above
		D018	included with above
		D019	included with above
		D020	included with above
		D021	included with above
		D022	included with above
		D023	included with above
		D024	included with above
		D025	included with above
		D026	included with above
		D027	included with above
		D028	included with above
		D029	included with above
		D030	included with above
		D031	included with above
		D032	included with above
		D033	included with above
		D034	included with above
		D035	included with above
		D036	included with above
		D037	included with above
		D038	included with above

PROCESS CODE	PROCESS DESIGN CAPACITY AND UNITS OF MEASURE	HAZARDOUS WASTE CODE	ANNUAL QUANTITY OF HAZARDOUS WASTE AND UNITS OF MEASURE
		D039	included with above
		D040	included with above
		D041	included with above
		D042	included with above
		D043	included with above
		F001	included with above
		F002	included with above
		F003	included with above
		F004	included with above
		F005	included with above
		F024	included with above
		F025	included with above
		~~F032*~~	~~included with above~~
		~~F033*~~	~~included with above~~
		F034	included with above
		F035	included with above
		F039	included with above
		K001	included with above
		~~K003~~	~~included with above~~
		~~K004~~	~~included with above~~
		~~K007~~	~~included with above~~
		K009	included with above
		K010	included with above
		K011	included with above
		K013	included with above
		K014	included with above
		K015	included with above
		K016	included with above
		K017	included with above
		K018	included with above

PROCESS CODE	PROCESS DESIGN CAPACITY AND UNITS OF MEASURE	HAZARDOUS WASTE CODE	ANNUAL QUANTITY OF HAZARDOUS WASTE AND UNITS OF MEASURE
TO3 (cont.)		P060	included with above
		P062	included with above
		P064	included with above
		P065	included with above
		P066	included with above
		P067	included with above
		P068	included with above
		P069	included with above
		P070	included with above
		P071	included with above
		P072	included with above
		P073	included with above
		P075	included with above
		P076	included with above
		P077	included with above
		P078	included with above
		P081	included with above
		P082	included with above
		P084	included with above
		P085	included with above
		P087	included with above
		P088	included with above
		P089	included with above
		P092	included with above
		P093	included with above
		P094	included with above
		P095	included with above
		P096	included with above
		P097	included with above
		P101	included with above
		P102	included with above
		P103	included with above
		P105	included with above
		P108	included with above
		P109	included with above
		P110	included with above
		P111	included with above
		P112	included with above
		P113	included with above
		P116	included with above
		P118	included with above
		P120	included with above
		P122	included with above
		P123	included with above
		U001	included with above
		U002	included with above
		U003	included with above
		U004	included with above
		U005	included with above
		U006	included with above
		U007	included with above
		U008	included with above

PROCESS CODE	PROCESS DESIGN CAPACITY AND UNITS OF MEASURE	HAZARDOUS WASTE CODE	ANNUAL QUANTITY OF HAZARDOUS WASTE AND UNITS OF MEASURE
TO3 (cont.)		U119	included with above
		U120	included with above
		U121	included with above
		U122	included with above
		U123	included with above
		U124	included with above
		U125	included with above
		U126	included with above
		U127	included with above
		U128	included with above
		U129	included with above
		U130	included with above
		U131	included with above
		U132	included with above
		U133	included with above
		U135	included with above
		~~U136~~	~~included with above~~
		U137	included with above
		U138	included with above
		U140	included with above
		U141	included with above
		U142	included with above
		U143	included with above
		U144	included with above
		U146	included with above
		U147	included with above
		U148	included with above
		U149	included with above
		U150	included with above
		U151	included with above
		U152	included with above
		U153	included with above
		U154	included with above
		U155	included with above
		U156	included with above
		U157	included with above
		U158	included with above
		U159	included with above
		U160	included with above
		U161	included with above
		U162	included with above
		U163	included with above
		U164	included with above
		U165	included with above
		U166	included with above
		U167	included with above
		U168	included with above
		U169	included with above
		U170	included with above
		U171	included with above
		U172	included with above

P. - INFORMATION REGARDING POTENTIAL RELEASES FROM SOLID WASTE MANAGEMENT UNITS

FACILITY NAME: Florida First Processing, L.P.

EPA I.D. NUMBER: FLD 982 134 555

LOCATION: City West side of Fort Green Rd, 3/4 mi south of County Rd 630, Polk County

State Florida

1. Are there any of the following solid waste management units (existing or closed) at your facility? NOTE - DO NOT INCLUDE HAZARDOUS WASTES UNITS CURRENTLY SHOWN IN YOUR PART B APPLICATION

	YES	NO
• Landfill		X
• Surface Impoundment		X
• Land Farm		X
• Waste Pile		X
• Incinerator		X
• Storage Tank (Above Ground)		X
• Storage Tank (Underground)		X
• Container Storage Area		X
• Injection Wells		X
• Wastewater Treatment Units		X
• Transfer Stations		X
• Waste Recycling Operations		X
• Land Treatment Facility		X

2. If there are "Yes" answers to any of the items in Number 1 above, please provide a description of the wastes that were stored, treated or disposed of in each unit. In particular please focus on whether or not the wastes would be considered as hazardous wastes or hazardous constituents under RCRA. Also include any available data on quantities or volumes of wastes disposed of and the dates of disposal. Please also provide a description of each unit and include capacity, dimensions, location at facility, provide a site plan if available.

N/A

NOTE: Hazardous waste are those identified in 40 CFR Part 261. Hazardous constituents are those listed in Appendix VIII of 40 CFR Part 261.

3. For the units noted in Number 1 above and also those hazardous waste units in your Part B application, please describe for each unit any data available on any prior or current releases of hazardous wastes or constituents to the environment that may have occurred in the past or still be occurring.

Please provide the following information:

a. Date of release
b. Type of waste released
c. Quantity or volume of waste released
d. Describe nature of release (i.e., spill, overflow, ruptured pipe or tank, etc)

N/A - Proposed Facility

4. In regard to the prior releases described in Number 3 above, please provide (for each unit) any analytical data that may be available which would describe the nature and extent of environmental contamination that exists as a result of such releases. Please focus on concentrations of hazardous wastes or constituents present in contaminated soil or groundwater.

N/A

Signature and Certification

As with reports in RCRA Permit Applications, submittal of this information must contain the following certification and signature by a principal executive officer of at least the level of Vice President or by a duly authorized representative of that person:

> I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Signature

Anthony F. Moscati, Jr., D. Env.
Name and Title (Typed)
Managing Director, FFP-LP

APPLICATION FOR A HAZARDOUS WASTE FACILITY PERMIT
CERTIFICATION
TO BE COMPLETED BY ALL APPLICANTS

1. OPERATOR

I CERTIFY UNDER PENALTY OF LAW THAT THIS DOCUMENT AND ALL ATTACHMENTS WERE PREPARED UNDER MY DIRECTION OR SUPERVISION IN ACCORDANCE WITH A SYSTEM DESIGNED TO ASSURE THAT QUALIFIED PERSONNEL PROPERLY GATHER AND EVALUATE THE INFORMATION SUBMITTED. BASED ON MY INQUIRY OF THE PERSON OR PERSONS WHO MANAGE THE SYSTEM, OR THOSE PERSONS DIRECTLY RESPONSIBLE FOR GATHERING THE INFORMATION, THE INFORMATION SUBMITTED IS, TO THE BEST OF MY KNOWLEDGE AND BELIEF, TRUE, ACCURATE, AND COMPLETE. I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION, INCLUDING THE POSSIBILITY OF FINE AND IMPRISONMENT FOR KNOWING VIOLATIONS. FURTHER, I AGREE TO COMPLY WITH THE PROVISIONS OF CHAPTER 403, FLORIDA STATUTES, AND ALL RULES AND REGULATIONS OF THE DEPARTMENT OF ENVIRONMENTAL REGULATION. IT IS UNDERSTOOD THAT THE PERMIT IS ONLY TRANSFERABLE IN ACCORDANCE WITH SECTION 17-30, FAC, AND, IF GRANTED A PERMIT, THE DEPARTMENT OF ENVIRONMENTAL REGULATION WILL BE NOTIFIED PRIOR TO THE SALE OR LEGAL TRANSFER OF THE PERMITTED FACILITY.

Anthony F. Moscati Jr.
SIGNATURE OF THE OPERATOR OR AUTHORIZED REPRESENTATIVE*

A. F. Moscati Jr., Managing Director
NAME AND TITLE (PLEASE TYPE OR PRINT)

DATE: Oct. 29, 1990 TELEPHONE NO. (703) 883-8270

*ATTACH A LETTER OF AUTHORIZATION

2. FACILITY OWNER

THIS IS TO CERTIFY THAT I UNDERSTAND THIS APPLICATION IS SUBMITTED FOR THE PURPOSE OF OBTAINING A PERMIT TO CONSTRUCT, OPERATE, OR CLOSE A HAZARDOUS WASTE MANAGEMENT FACILITY ON THE PROPERTY AS DESCRIBED. AS OWNER OF THE FACILITY, I UNDERSTAND FULLY THAT THE FACILITY OPERATOR AND I ARE JOINTLY RESPONSIBLE FOR COMPLIANCE WITH THE PROVISIONS OF CHAPTER 403, FLORIDA STATUTES, AND ALL RULES AND REGULATIONS OF THE DEPARTMENT OF ENVIRONMENTAL REGULATION.

Anthony F. Moscati Jr.
SIGNATURE OF THE FACILITY OWNER OR AUTHORIZED REPRESENTATIVE*

A. F. Moscati Jr., Managing Director
NAME AND TITLE (PLEASE TYPE OR PRINT)

DATE: Oct. 29, 1990 TELEPHONE NO. (703) 883-8270

*ATTACH A LETTER OF AUTHORIZATION

3 LAND OWNER

THIS IS TO CERTIFY THAT I, AS LAND OWNER, UNDERSTAND THAT THIS APPLICATION IS SUBMITTED FOR THE PURPOSE OF OBTAINING A PERMIT TO CONSTRUCT, OPERATE, OR CLOSE A HAZARDOUS WASTE MANAGEMENT FACILITY ON THE PROPERTY AS DESCRIBED. FOR HAZARDOUS WASTE DISPOSAL FACILITIES, I FURTHER UNDERSTAND THAT I AM RESPONSIBLE FOR PROVIDING THE NOTICE IN THE DEED TO THE PROPERTY REQUIRED BY 40 CFR §264.119 AND §265.119, AS ADOPTED BY REFERENCE IN CHAPTER 17-30, FAC.

SIGNATURE OF THE FACILITY OWNER OR AUTHORIZED REPRESENTATIVE*

Anthony F. Moscati Jr. - Managing Director
NAME AND TITLE (PLEASE TYPE OR PRINT)

DATE: Oct 29, 1990 TELEPHONE NO. 203 883-8220

*ATTACH A LETTER OF AUTHORIZATION

4. PROFESSIONAL ENGINEER REGISTERED IN FLORIDA (WHERE REQUIRED BY CHAPTER 471, F.S.)

*THIS IS TO CERTIFY THAT THE ENGINEERING FEATURES OF THIS HAZARDOUS WASTE MANAGEMENT FACILITY HAVE BEEN DESIGNED/EXAMINED BY ME AND FOUND TO CONFORM TO ENGINEERING PRINCIPLES APPLICABLE TO SUCH FACILITIES. IN MY PROFESSIONAL JUDGMENT, THIS FACILITY, WHEN PROPERLY CONSTRUCTED, MAINTAINED AND OPERATED, OR CLOSED, WILL COMPLY WITH ALL APPLICABLE STATUTES OF THE STATE OF FLORIDA AND RULES OF THE DEPARTMENT OF ENVIRONMENTAL REGULATION.

SIGNATURE ______ MAILING ADDRESS ______

NAME Dick M. Miller International Waste Energy Systems, Inc. (PLEASE TYPE)

Robinson Plaza II Suite 200
STREET OR P.O. BOX

*See attached letter

Pittsburgh, PA 15205
CITY STATE ZIP

(412) 281 5222
TELEPHONE NO.

11/2/90
DATE

FLORIDA REGISTRATION NUMBER: 20927

(Please Affix Seal)

DICK M. MILLER
CERTIFICATE
No. 20927
STATE OF FLORIDA
REGISTERED ENGINEER

IWES

International Waste Energy Systems

November 5, 1990

Dr. Anthony Moscati, Jr.
Managing Director
Florida First Processing, L.P.
8150 Leesburg Pike
Vienna, Virginia 22182

Re: Engineer's Certification
RCRA Part B Application
FLD 982 134 555

Dear Dr. Moscati:

Enclosed you will find a signed and stamped engineer's certification to be included in your Part B application. This certification applies to the Florida First Processing, L.P. facility to be built in Polk County, Florida. By means of inclusion in your Part B application, I am certifying the design of the facility as originally submitted on May 31, 1989 as well as revisions submitted on September 29, 1989 and October 29, 1990.

If I can be of further assistance, please do not hesitate to call me.

Very truly yours,
INTERNATIONAL WASTE
ENERGY SYSTEMS

Dick M. Miller
President

DMM:seb

enclosure

9010-1011-013

International Waste Energy Systems
Robinson Plaza II
Suite 200
Pittsburgh, PA 15205
(412) 281-5222 / TeleFAX (412) 281-5220

A Division of *ICF KAISER ENGINEERS*

Please print or type with ELITE type (12 characters per inch) in the unshaded areas only

Form Approved. OMB No. 2050-0028. Expires 10-31-91
GSA No. 0246-EPA-OT

Please refer to the *Instructions for Filing Notification* before completing this form. The information requested here is required by law *(Section 3010 of the Resource Conservation and Recovery Act)*.

EPA Notification of Regulated Waste Activity

United States Environmental Protection Agency

Date Received (For Official Use Only)

I. Installation's EPA ID Number *(Mark 'X' in the appropriate box)*

[ ] A. First Notification
[X] B. Subsequent Notification *(complete item C)*

C. Installation's EPA ID Number: F L D 9 8 2 1 3 4 5 5 5

II. Name of Installation *(Include company and specific site name)*

Florida First Processing, L. P.

III. Location of Installation *(Physical address not P.O. Box or Route Number)*

Street: Fort Green Rd, 3/4 mile south of County Road, Polk County

Street (continued):

City or Town: | State: FL | ZIP Code: -

County Code: | County Name: POLK

IV. Installation Mailing Address *(See Instructions)*

Street or P.O. Box: 8150 Leesburgh Pike , Suite 700

City or Town: Vienna , | State: VA | ZIP Code: 22182 -

V. Installation Contact *(Person to be contacted regarding waste activities at site)*

Name *(last)*: Moscati, Jr. | *(first)*: Anthony, F.

Job Title: Managing Director | Phone Number *(area code and number)*: 703-883-8270

VI. Installation Contact Address *(See Instructions)*

A. Contact Address: Location [ ] Mailing [X]

B. Street or P.O. Box: 8150 Leesburgh Pike Suite 700

City or Town: Vienna | State: VA | ZIP Code: 22182 -

VII. Ownership *(See Instructions)*

A. Name of Installation's Legal Owner: Florida First Processing, L. P.

Street, P.O. Box, or Route Number: 8150 Leesburgh Pike Suite 700

City or Town: Vienna | State: VA | ZIP Code: 22182 -

Phone Number *(area code and number)*	B. Land Type	C. Owner Type	D. Change of Owner Indicator	(Date Changed) Month	Day	Year
703-883-8270		P	Yes X No	10	15	90

EPA Form 8700-12 (01-90) Previous edition is obsolete.

Continue on reverse

ID — For Official Use Only														
C													T/A	C
W														1

X. Description of Hazardous Wastes *(continued from front)*

A. Hazardous Wastes from Nonspecific Sources. Enter the four-digit number from 40 *CFR* Part 261.31 for each listed hazardous waste from nonspecific sources your installation handles. Use additional sheets if necessary. See Attached Sheets

1	2	3	4	5	6
7	8	9	10	11	12

B. Hazardous Wastes from Specific Sources. Enter the four-digit number from 40 *CFR* Part 261.32 for each listed hazardous waste from specific sources your installation handles. Use additional sheets if necessary. See Attached Sheets

13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30

C. Commercial Chemical Product Hazardous Wastes. Enter the four-digit number from 40 *CFR* Part 261.33 for each chemical substance your installation handles which may be a hazardous waste. Use additional sheets if necessary. See Attached Sheets

31	32	33	34	35	36
37	38	39	40	41	42
43	44	45	46	47	48

D. Listed Infectious Wastes. Enter the four-digit number from 40 *CFR* Part 261.34 for each hazardous waste from hospitals, veterinary hospitals, or medical and research laboratories your installation handles. Use additional sheets if necessary.

49	50	51	52	53	54
N / A					

E. Characteristics of Nonlisted Hazardous Wastes. Mark 'X' in the boxes corresponding to the characteristics of nonlisted hazardous wastes your installation handles. *(See 40 CFR Parts 261.21 — 261.24)*

- [X] 1. Ignitable *(D001)*
- [X] 2. Corrosive *(D002)*
- [X] 3. Reactive *(D003)*
- [X] 4. Toxic *(D000)*

XI. Certification

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Signature	Name and Official Title *(type or print)*	Date Signed
Anthony F. Moscati	DR. ANTHONY F. MOSCATI, JR. MANAGING DIRECTOR, FFP-LP	Oct 29, 1990

ATTACHMENT TO EPA FORM 8700-12

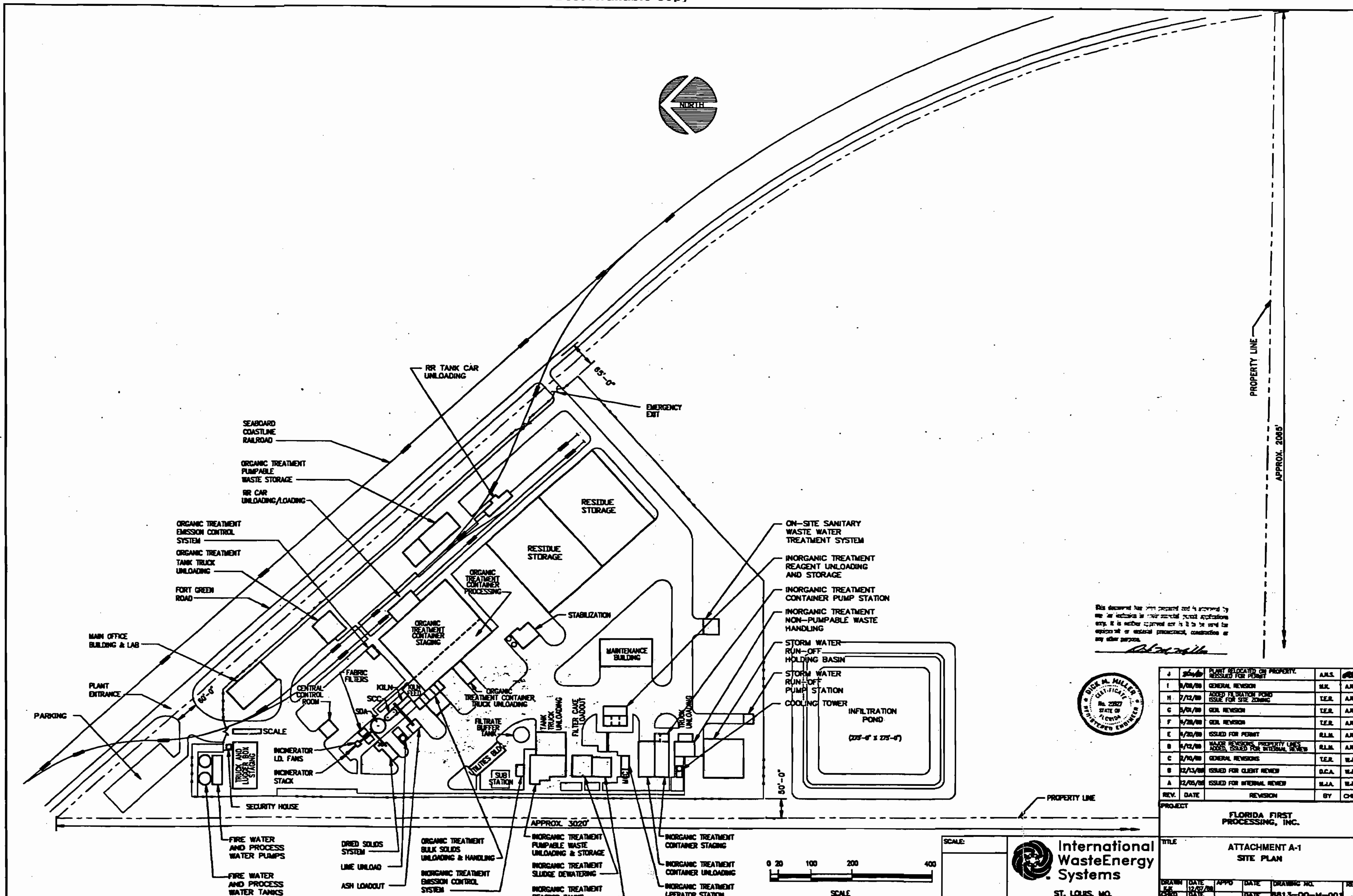
IX.A.	D004	D007	D010	D013	D016	
	D005	D008	D011	D014	D017	
	D006	D009	D012	D015		
IX.B.	F001	F005	F009	F019	F033*	
	F002	F006	F010	F024	F034	
	F003	F007	F011	F025	F035	
	F004	F008	F012	F032*	F039	
	K001	K017	K032	K051	K087	K104
	K002	K018	K033	K052	K088	K105
	K003	K019	K034	K060	K090	K106
	K004	K020	K035	K061	K091	K111
	K005	K021	K036	K062	K093	K112
	K006	K022	K037	K064	K094	K113
	K007	K023	K038	K065	K095	K114
	K008	K024	K039	K066	K096	K115
	K009	K025	K040	K069	K097	K116
	K010	K026	K041	K071	K098	K117
	K011	K027	K042	K073	K099	K118
	K013	K028	K043	K083	K100	K123
	K014	K029	K048	K084	K101	K124
	K015	K030	K049	K085	K102	K125
	K016	K031	K050	K086	K103	K126
						K136
	P001	P028	P058	P088	P118	U021
	P002	P029	P059	P089	P119	U022
	P003	P030	P060	P092	P120	U023
	P004	P031	P062	P093	P121	U024
	P005	P033	P063	P094	P122	U025
	P006	P034	P064	P095	P123	U026
	P007	P036	P065	P096	U001	U027
	P008	P037	P066	P097	U002	U028
	P009	P038	P067	P098	U003	U029
	P010	P039	P068	P099	U004	U030
	P011	P040	P069	P101	U005	U031
	P012	P041	P070	P102	U006	U032
	P013	P042	P071	P103	U007	U033
	P014	P043	P072	P104	U008	U034
	P015	P044	P073	P105	U009	U035
	P016	P045	P074	P106	U010	U036
	P017	P046	P075	P108	U011	U037
	P018	P047	P076	P109	U012	U038
	P020	P048	P077	P110	U014	U039
	P021	P049	P078	P111	U015	U041
	P022	P050	P081	P112	U016	U042
	P023	P051	P082	P113	U017	U043
	P024	P054	P084	P114	U018	
	P026	P056	P085	P115	U019	
	P027	P057	P087	P116	U020	

*These waste codes may include pentachlorophenol as one possible constituent. The facility will only accept wastes classified under these codes which do not contain pentachlorophenol.

Date: 10/15/90
Revision: 2

U044	U078	U112	U145	U178	U214
U045	U079	U113	U146	U179	U215
U046	U080	U114	U147	U180	U216
U047	U081	U115	U148	U181	U217
U048	U082	U116	U149	U182	U218
U049	U083	U117	U150	U183	U219
U050	U084	U118	U151	U184	U220
U051	U085	U119	U152	U185	U221
U052	U086	U120	U153	U186	U222
U053	U087	U121	U154	U187	U223
U055	U088	U122	U155	U188	U225
U056	U089	U123	U156	U189	U226
U057	U090	U124	U157	U190	U227
U058	U091	U125	U158	U191	U228
U059	U092	U126	U159	U192	U234
U060	U093	U127	U160	U193	U235
U061	U094	U128	U161	U194	U236
U062	U095	U129	U162	U196	U237
U063	U096	U130	U163	U197	U238
U064	U097	U131	U164	U200	U239
U066	U098	U132	U165	U201	U240
U067	U099	U133	U166	U202	U243
U068	U101	U134	U167	U203	U244
U069	U102	U135	U168	U204	U245
U070	U103	U136	U169	U205	U246
U071	U105	U137	U170	U206	U247
U072	U106	U138	U171	U207	U248
U073	U107	U140	U172	U208	U249
U074	U108	U141	U173	U209	U328
U075	U109	U142	U174	U210	U353
U076	U110	U143	U176	U211	U359
U077	U111	U144	U177	U213	

Best Available Copy



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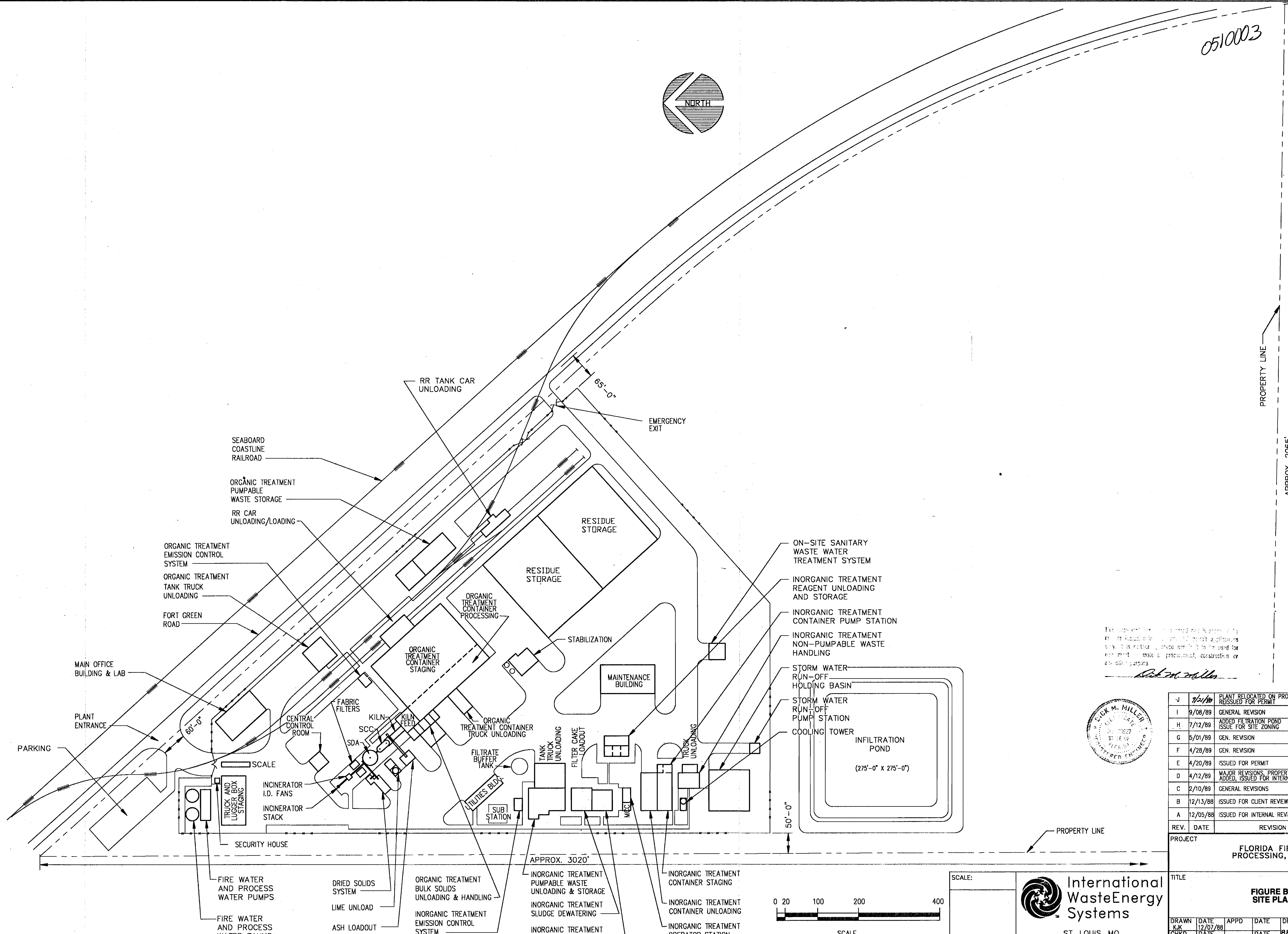


This document [illegible] permit applications only. It is neither approved nor is it to be used for equipment or material procurement, construction or any other purpose.

Dick M. Miller

DICK M. MILLER [illegible] STATE OF FLORIDA REGISTERED ENGINEER

REV.	DATE	REVISION	BY	CHKD
J	9/21/90	PLANT RELOCATED ON PROPERTY. REISSUED FOR PERMIT	A.N.S.	[illegible]
I	9/08/89	GENERAL REVISION	M.K.	A.N.S.
H	7/12/89	ADDED FILTRATION POND ISSUE FOR SITE ZONING	T.E.R.	A.N.S.
G	5/01/89	GEN. REVISION	T.E.R.	A.N.S.
F	4/28/89	GEN. REVISION	T.E.R.	A.N.S.
E	4/20/89	ISSUED FOR PERMIT	R.L.M.	A.N.S.
D	4/12/89	MAJOR REVISIONS, PROPERTY LINES ADDED, ISSUED FOR INTERNAL REVIEW	R.L.M.	A.N.S.
C	2/10/89	GENERAL REVISIONS	T.E.R.	W.J.H.
B	12/13/88	ISSUED FOR CLIENT REVIEW	D.C.A.	W.J.H.
A	12/05/88	ISSUED FOR INTERNAL REVIEW	M.J.A.	W.J.H.

8813M001.DWG

SCALE:

International WasteEnergy Systems
ST. LOUIS, MO.

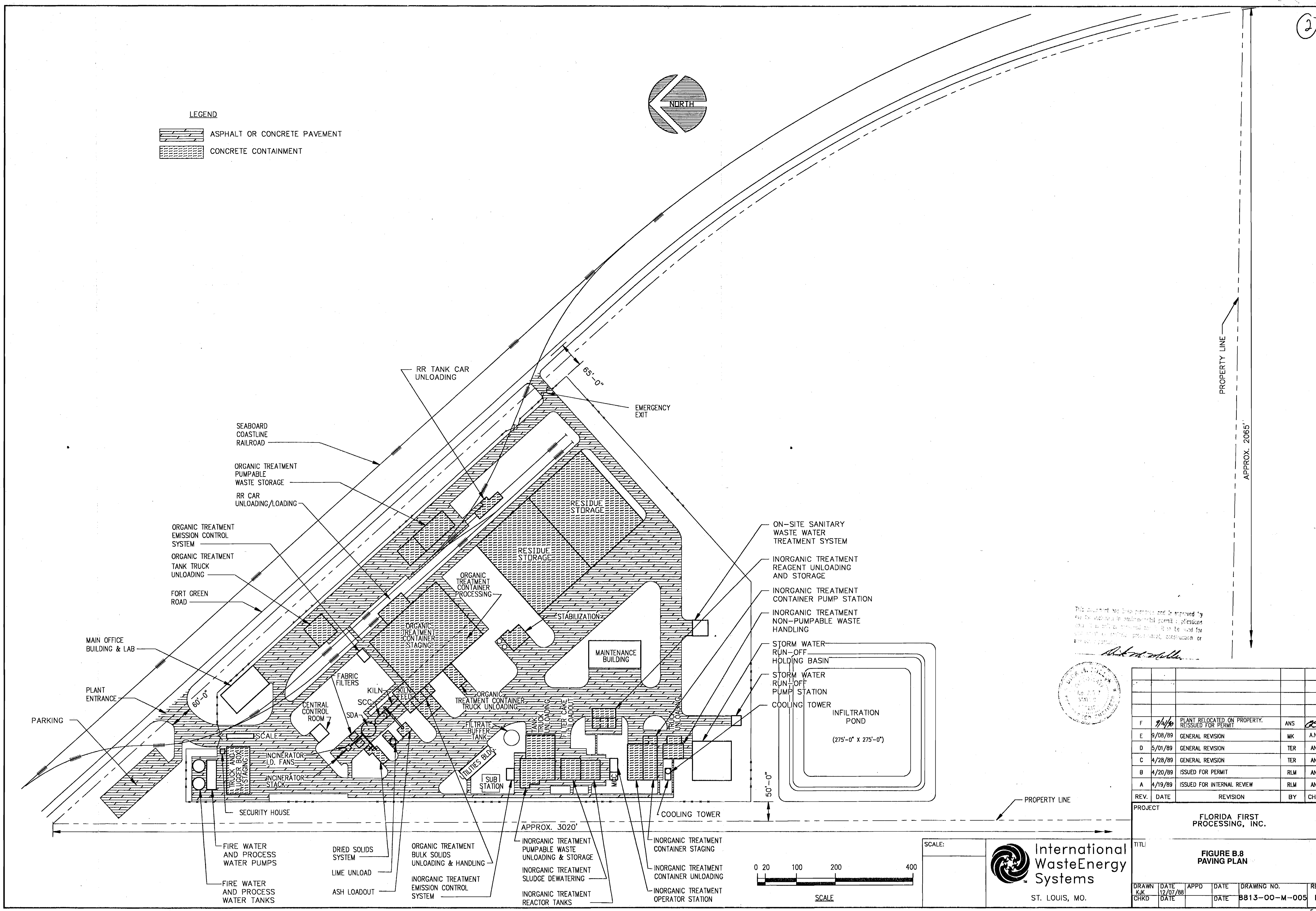
PROJECT
FLORIDA FIRST PROCESSING, INC.

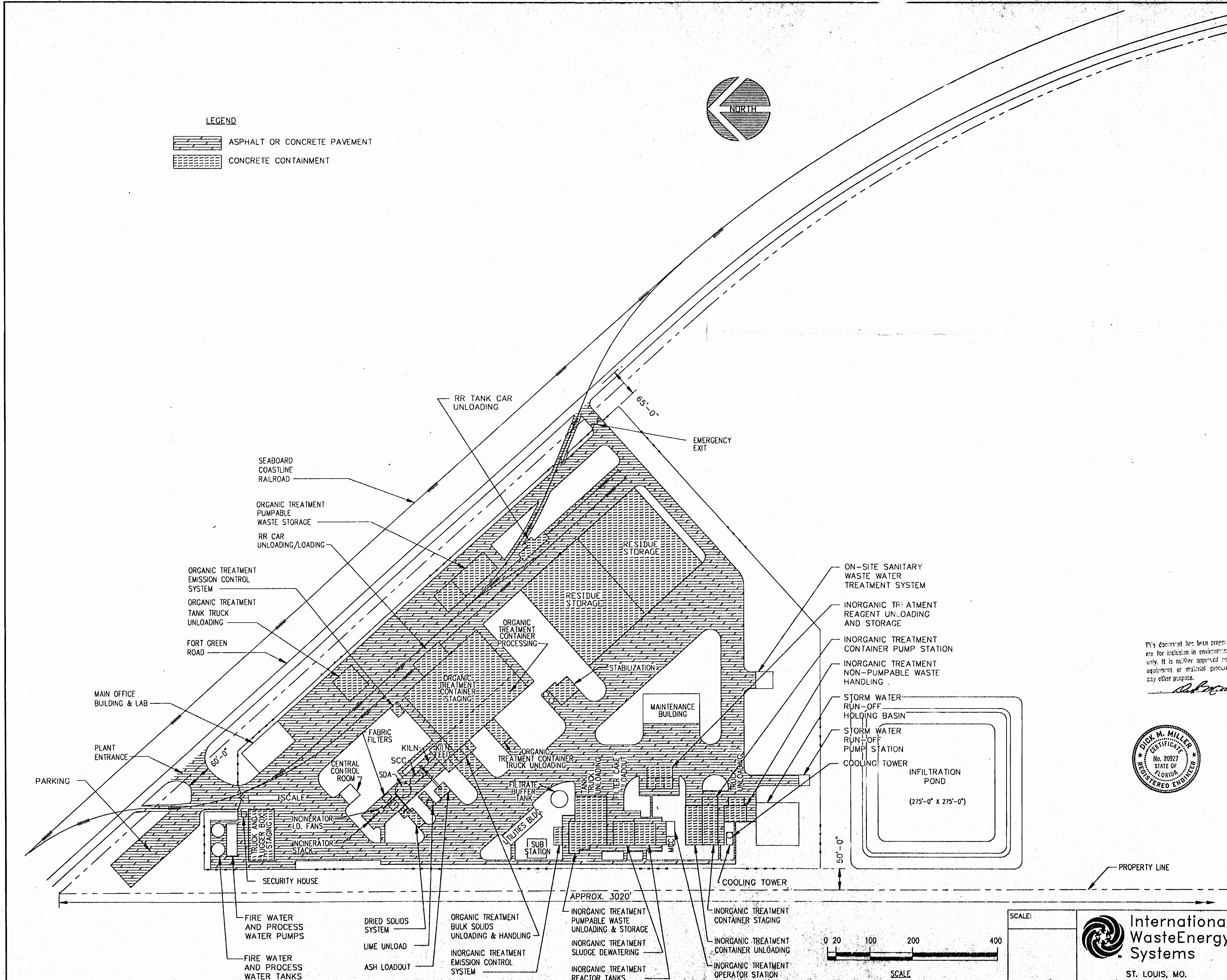
TITLE
FIGURE B.4
SITE PLAN

DRAWN	DATE	APPD	DATE	DRAWING NO.	REV.
KJK	12/07/88			8813-00-M-001	J
CHKD	DATE		DATE		

J-5

Best Available Copy





This document has been prepared and is approved by me for inclusion in environmental permit applications only. It is neither approved nor is it to be used for equipment or material procurement, construction or any other purpose.

DICK M. MILLER CERTIFICATE No. 20927 STATE OF FLORIDA REGISTERED ENGINEER

REV.	DATE	REVISION	BY	CHKD
G	12/3/90	GENERAL REVISION REISSUED FOR PERMIT	ANS	
F	9/21/90	PLANT RELOCATED ON PROPERTY. REISSUED FOR PERMIT	ANS	GCS
E	8/08/89	GENERAL REVISION	MK	A.N.S.
D	6/01/89	GENERAL REVISION	TER	ANS
C	4/28/89	GENERAL REVISION	TER	ANS
B	4/20/89	ISSUED FOR PERMIT	RLM	ANS
A	4/19/89	ISSUED FOR INTERNAL REVIEW	RLM	ANS

PROJECT
FLORIDA FIRST PROCESSING, INC.

SCALE:

International WasteEnergy Systems
ST. LOUIS, MO.

TITLE
FIGURE B.8
PAVING PLAN

DRAWN	DATE	APPD	DATE	DRAWING NO.	REV.
K.K	12/07/88			8813-00-M-005	G
CHKD	DATE		DATE		

FILE NAME: 8813M005.DWG

G-1

(3)

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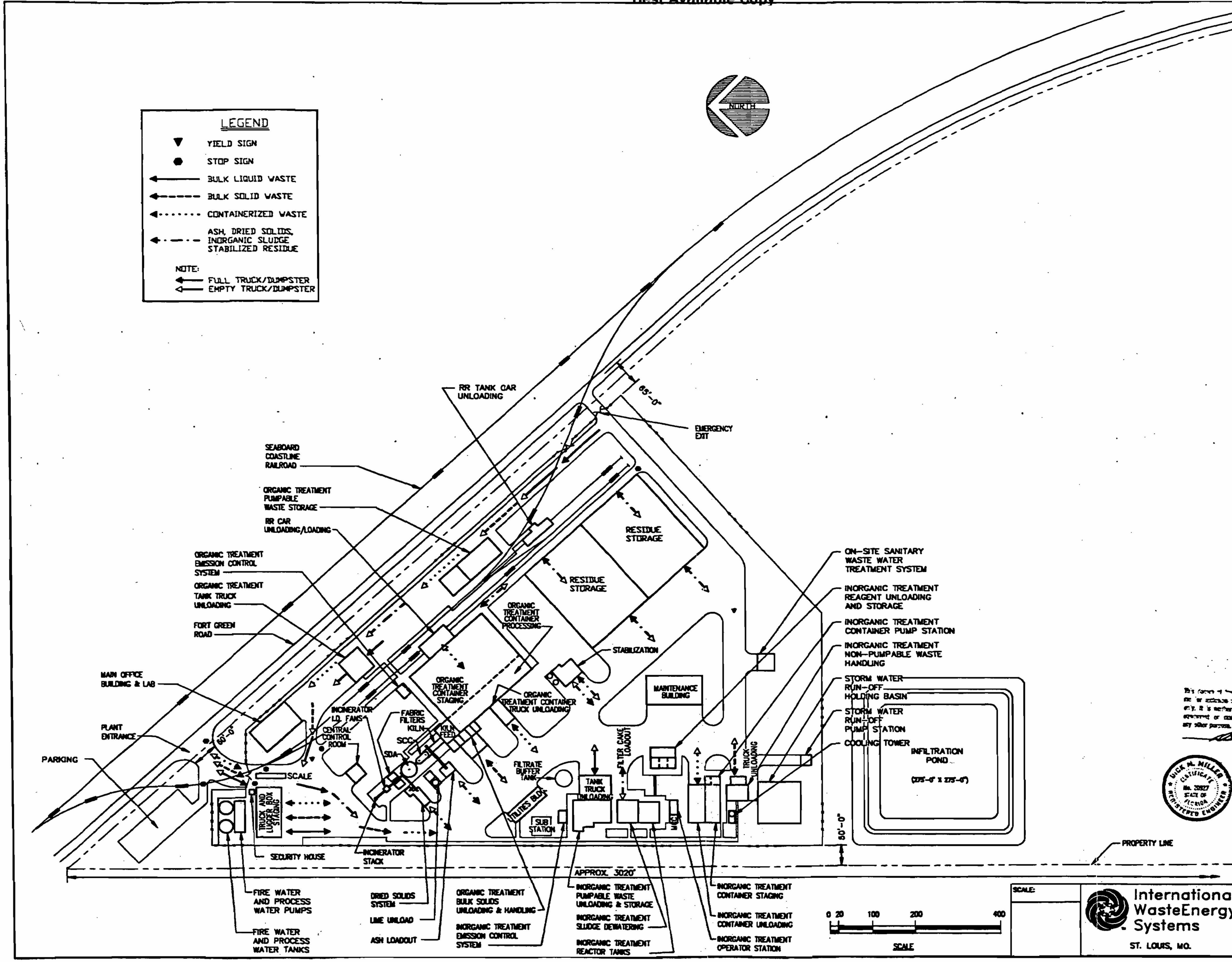


REV.	DATE	REVISION	BY	CHKD
F		PLANT RELOCATED ON PROPERTY. REISSUED FOR PERMIT	ANS	
E	08/08/88	GENERAL REVISION	MK	ANS
D	05/01/88	GENERAL REVISION	TER	ANS
C	04/28/88	GENERAL REVISION	TER	ANS
B	04/20/88	ISSUED FOR PERMIT	RLM	ANS
A	04/18/88	ISSUED FOR INTERNAL REVIEW	RLM	ANS

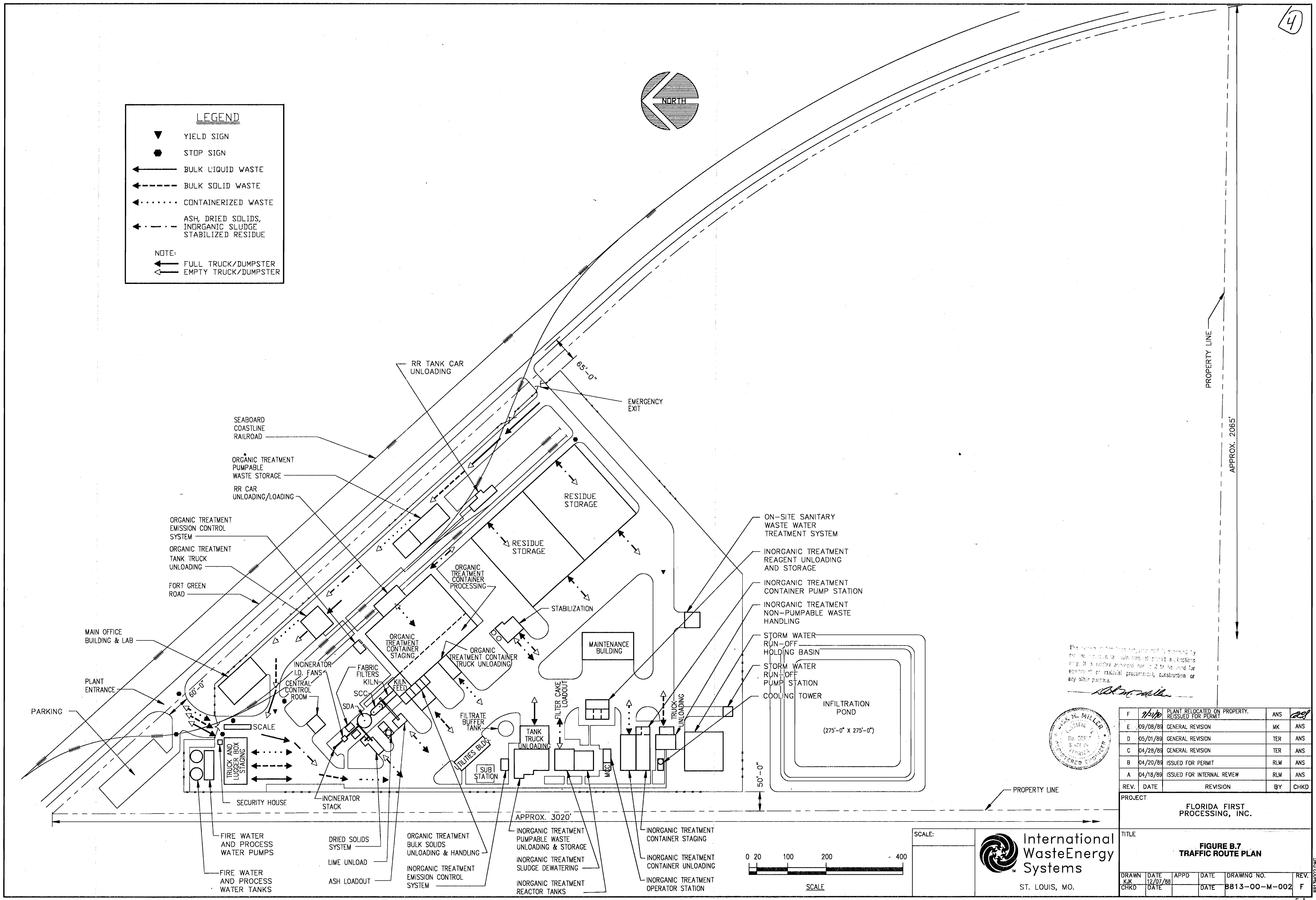
SCALE:

International WasteEnergy Systems
ST. LOUIS, MO.

PROJECT
FLORIDA FIRST PROCESSING, INC.

TITLE
ATTACHMENT A-3
TRAFFIC ROUTE PLAN

DRAWN	DATE	APPD	DATE	DRAWING NO.	REV.
KJK	12/07/88			8813-00-M-002	F
CHKD	DATE		DATE		



4
NORTH
LEGEND
YIELD SIGN
STOP SIGN
BULK LIQUID WASTE
BULK SOLID WASTE
CONTAINERIZED WASTE
ASH, DRIED SOLIDS, INORGANIC SLUDGE STABILIZED RESIDUE
NOTE:
FULL TRUCK/DUMPSTER
EMPTY TRUCK/DUMPSTER
RR TANK CAR UNLOADING
65'-0"
EMERGENCY EXIT
SEABOARD COASTLINE RAILROAD
ORGANIC TREATMENT PUMPABLE WASTE STORAGE
RR CAR UNLOADING/LOADING
ORGANIC TREATMENT EMISSION CONTROL SYSTEM
ORGANIC TREATMENT TANK TRUCK UNLOADING
FORT GREEN ROAD
MAIN OFFICE BUILDING & LAB
PLANT ENTRANCE
PARKING
60'-0"
RESIDUE STORAGE
RESIDUE STORAGE
ORGANIC TREATMENT CONTAINER PROCESSING
STABILIZATION
ORGANIC TREATMENT CONTAINER STAGING
ORGANIC TREATMENT CONTAINER TRUCK UNLOADING
MAINTENANCE BUILDING
INCINERATOR I.D. FANS
FABRIC FILTERS
KILN
KILN FEED
CENTRAL CONTROL ROOM
SCC
SDA
SCALE
FILTRATE BUFFER TANK
UTILITIES BLDG.
SUB STATION
TANK TRUCK UNLOADING
FILTER CAKE LOADOUT
TRUCK UNLOADING
MCC
TRUCK AND LUGGER BOX STAGING
SECURITY HOUSE
INCINERATOR STACK
ON-SITE SANITARY WASTE WATER TREATMENT SYSTEM
INORGANIC TREATMENT REAGENT UNLOADING AND STORAGE
INORGANIC TREATMENT CONTAINER PUMP STATION
INORGANIC TREATMENT NON-PUMPABLE WASTE HANDLING
STORM WATER RUN-OFF HOLDING BASIN
STORM WATER RUN-OFF PUMP STATION
COOLING TOWER
INFILTRATION POND
(275'-0" X 275'-0")
PROPERTY LINE
APPROX. 2065'
PROPERTY LINE
50'-0"
APPROX. 3020'
FIRE WATER AND PROCESS WATER PUMPS
FIRE WATER AND PROCESS WATER TANKS
DRIED SOLIDS SYSTEM
LIME UNLOAD
ASH LOADOUT
ORGANIC TREATMENT BULK SOLIDS UNLOADING & HANDLING
INORGANIC TREATMENT EMISSION CONTROL SYSTEM
INORGANIC TREATMENT PUMPABLE WASTE UNLOADING & STORAGE
INORGANIC TREATMENT SLUDGE DEWATERING
INORGANIC TREATMENT REACTOR TANKS
INORGANIC TREATMENT CONTAINER STAGING
INORGANIC TREATMENT CONTAINER UNLOADING
INORGANIC TREATMENT OPERATOR STATION
0 20 100 200 400
SCALE
SCALE:
International WasteEnergy Systems
ST. LOUIS, MO.
F 9/21/90 PLANT RELOCATED ON PROPERTY. REISSUED FOR PERMIT ANS
E 09/08/89 GENERAL REVISION MK ANS
D 05/01/89 GENERAL REVISION TER ANS
C 04/28/89 GENERAL REVISION TER ANS
B 04/20/89 ISSUED FOR PERMIT RLM ANS
A 04/18/89 ISSUED FOR INTERNAL REVIEW RLM ANS
REV. DATE REVISION BY CHKD
PROJECT
FLORIDA FIRST PROCESSING, INC.
TITLE
FIGURE B.7
TRAFFIC ROUTE PLAN
DRAWN KJK DATE 12/07/88 APPD DATE DRAWING NO. 8813-00-M-002 REV. F
CHKD DATE DATE
8813M002.DWG
F-3

SECTION B

FACILITY DESCRIPTION

This section provides a general description of the Florida First Processing, L.P. (FFP-LP) facility as required by 40 CFR 270.14(b) (40 CFR 270 is incorporated by reference in F.A.C. 17-730.200). Included in this section are information on the location of the facility and description of adjacent areas, in the form of a site plan, topographic maps, a floodplain map, and a legal description of the site. Additionally, a summary of site operations is given. This description includes site history, proposed waste management operations, traffic patterns, and other relevant information.

B.1 GENERAL DESCRIPTION

The FFP-LP facility will be located at Fort Green Road south of the town of Bradley Junction and north of the town of Baird in Polk County, Florida. The legal facility boundaries will encompass 82.7 acres of land situated in Section 1, Township 32 South, Range 23 East, Polk County, Florida.

The facility will be located in an area that is currently zoned Rural Conservation (RC) Agricultural. FFP-LP is in the process of applying for rezoning of the property to General Industrial (GI). The advisory board presentation is expected in ~~August, 1989~~ Spring, 1991. The property will be rezoned before construction is initiated. A number of reclaimed phosphate strip mines surround the facility, and some marshy areas in the area have been filled in. There are a few manufacturing/processing firms in the nearby town of Bradley Junction which is five miles north. Other towns, e.g., Bartow, Fort Mead, Mulberry, and Winter Haven, are approximately ten to fifteen miles away.

Sparsely populated areas are located approximately two or more miles away. The closest residential area is a trailer park consisting of nine homes located approximately two miles southeast of the facility, as shown on the USGS Topographic Map in Figure B.1.

B.2 SITE OPERATIONS

The Florida First Processing, L.P.. facility will receive industrial wastes to be processed through the rotary kiln incineration unit and through cyanide or multi-purpose inorganic treatment reactors. These wastes will be transported from the generators to the facility in bulk (e.g., in tank trucks, tank railcars) and in containers (e.g., drums). The bulk wastes will be stored in tanks or pumped directly to the processing units. Containerized wastes will be stored in container staging areas, or pumped into storage tanks or directly into processing units.

Process residuals from site operations such as incinerator ash, fabric filter dust, spray dryer absorber residues, and inorganic treatment filter cake will be stabilized/solidified and stored on-site or sent off-site to approved treatment, storage, and disposal facilities. Effluent from the inorganic treatment reactors will be treated at an on-site wastewater treatment facility and re-used as cooling or spray dry water in the incineration unit. An in-depth description of site operations is given in Section D of this permit application.

B.3 TOPOGRAPHIC MAP INFORMATION

Figure B.1 is a USGS map for the Baird, Florida Quadrangle which shows the facility and its surrounding areas, including the reclaimed strip mines and the surface water bodies. This map also shows current land uses of the surrounding areas. Figure B.2 is a property survey map showing the legal boundaries of the facility. Figure B.3 is a more detailed topographic map showing areas within the facility boundaries at a scale of 1 inch to 200 feet, with contours at an interval of 2 feet. The land surrounding the facility is being reclaimed by the owners of that property, and the topographic map will be upgraded to reflect the topography as information is received from the surrounding property owners. Figure B.4 is a site plan showing the proposed buildings, unloading/loading areas, waste storage areas, rotary kiln incinerator, inorganic treatment reactors, and other details of the facility.

An annual wind rose of meteorological data collected from 1948 to 1978 at the nearest airport at Tampa, approximately 35 miles northwest of the facility, is shown in Figure B.5.

~~Drainage controls around the waste management areas of the facility are shown in Drawing 8813-00-S-014 in Appendix D-5.~~ Moved to Section B.4.2

B.4 LOCATION INFORMATION

As required by 40 CFR 270.14(b)(11), information on whether the facility comes under the seismic and floodplain standards is provided below. Both these standards are not applicable for areas within FFP-LP which will treat, process, or store hazardous wastes.

B.4.1 Seismic Standard

The Florida First Processing, L.P.. facility is located in Polk County, Florida, which is not listed in 40 CFR 264, Appendix VI, as an area subject to seismic activity. Hence, no further information or demonstration is necessary.

B.4.2 Floodplain Standard

Figure B.6 is a Flood Insurance Rate Map for the facility and surrounding areas obtained from the Federal Insurance Administration. Facility boundaries and proposed waste management areas are drawn on this map. There are two areas within facility boundaries, one in the northern corner and another along the southern boundary, which may be affected by a 100-year flood, designated as Zone A. The northern zone A area has been filled in by the previous landowner, as is shown in the aerial photographs in Section A. ~~The waste management areas within the facility will be constructed outside the 100-year floodplain (Zone A areas) and hence need not be designed to withstand a 100-year flood.~~ A review of the Flood Insurance Rate Map for the site was conducted by a registered Florida professional engineer. This review determined that the 100 year flood does not appear to have any hydrodynamic or hydrostatic impacts on the facility and adjoining site as designed. A copy of this report is presented in Figure B-6a. The facility site drainage will be designed to handle a 100 year flood rainfall event. Drainage controls around the waste management areas of the facility are shown in Drawing 8813-00-S-014 in Appendix D-5.

B.5 TRAFFIC INFORMATION

Traffic routing and control at the Florida First Processing, L.P.. facility, as shown in Figure B.7, will allow for the free and safe access of routine and emergency vehicles onto and within the facility in the vicinity of the waste management areas and ancillary facilities. This information is provided in accordance with 40 CFR 270.14(b)(10).

Truck access to the facility will be through the main gate on Fort Green Road about one mile from County Route 630. Route 630 is classified as a medium-duty road, while Fort Green Road, which is used for a short distance, is a light-duty one. Trucks carrying bulk or containerized wastes from industrial facilities will generally take Route 98 from the north or Route 17 from the south to get to Route 630. Railcars will arrive at the facility on the CSX Transportation Railroad which travels beside Fort Green Road.

Within the facility, employees' personal cars will be confined to the entrance road and parking lot. Other traffic will consist mostly of trailer or tank trucks which may enter the facility 24 hours each working day. Most waste shipments will be received during the day shift. Over-the-road movement of hazardous waste will be limited to the entrance and site roads leading up to the unloading/loading areas. The hazardous wastes will then be transferred to the diked container staging areas, or pumped through closed lines to storage tanks or to the processing units.

The load-bearing capacity of all access and facility roads will be equal to or greater than 2,000 pounds per square inch. All the county routes are and facility roads will be constructed of blacktop asphalt pavement. The facility paving plan is shown in Figure B.8. The roads and railroad used for transporting hazardous wastes will sufficiently handle the load and volume of traffic to and from the facility. An estimate of 5 railcars, 15 trucks, and 180 personal or commercial vehicles will arrive at the facility each day.

B.6 SOLID WASTE MANAGEMENT UNITS

The Florida First Processing, L.P. facility will have several storage and process tanks, and waste management equipment used in container processing, incineration, and inorganic treatment. The proposed location of these units is identified in Figure B.4 as well as in Section D (Process Information) of this permit application. Process and instrumentation diagrams, data sheets, and specification drawings are provided in Appendix D-5 of Section D to identify the type, operation, and function of each proposed waste management unit at the facility. The characterization of the hazardous wastes that will be managed at these units is given in Section C (Waste

Characteristics) and Appendix C (Waste Analysis Plan) of this application. This information is provided in accordance with 40 CFR 270.14(d).

In the event of a release of hazardous wastes from these units, all necessary company resources will be committed to take the action outlined in Section G (Contingency Plan). At that time, ~~corrective~~ emergency response procedures will be instituted to protect human health and the environment, in accordance with 40 CFR 264.51 (40 CFR 264 is incorporated by reference in F.A.C. 17-730.180). Additionally, applicable requirements of 40 CFR 264.101 will also be met by initiating a corrective action program to address such a release. Information of such corrective action is not applicable at this stage, but will be provided at the time of any unforeseen release of hazardous wastes. Since the facility is not a land-based disposal facility, the requirements of 40 CFR 264.91 to 264.100 are not pertinent.

B.7. RECORDKEEPING AND REPORTING REQUIREMENTS

If FFP-LP plans to receive hazardous wastes from a foreign source, it will notify the Regional Administrator of EPA and the Secretary of the DER in writing at least four weeks in advance of the date the waste is expected to arrive at FFP-LP, in accordance with 40 CFR 264.12(a).

As stated in 40 CFR 264.12(b), FFP-LP will inform in writing each generator that transports hazardous waste to the facility that the facility has the appropriate permit(s) for, and will accept, the waste the generator is shipping. FFP-LP will keep a copy of this written notice as part of its operating record.

Before transferring ownership or operation of the facility during its operating life, FFP-LP will notify the new owner or operator in writing of the requirements of 40 CFR 264 and 270, as well as all additional requirements of Chapter 17-730, FAC (including, but not limited to reporting requirements of 17-730.180(6), in accordance with 40 CFR 264.12(c).

The requirements stated under 40 CFR 264.70 through 264.72 are addressed in Section 2.2, Waste Receipt Procedures, of the Waste Analysis Plan. As required under 40 CFR 264.75 and FAC 17-730.180(6), FFP-LP will prepare and submit a single copy of a biennial report (or annual report, if 17-730.180(6) is changed to reflect such frequency) to the department by March 1 of each even numbered year (or every year if required by 17-730.180(6)). The biennial report will be submitted on DER Form 17-730.900(3). The report will cover facility activities during the previous calendar year and will include:

(a) The EPA identification number, name, and address of the facility;

(b) The calendar year covered by the report;

(c) The EPA identification number of each hazardous waste generator from which the facility received a hazardous waste during the year; for imported shipments, the report will give the name and address of the foreign generator;

(d) A description and the quantity of each hazardous waste the facility received during the year. This information will be listed by EPA identification number of each generator;

(e) The method of treatment, storage, or disposal for each hazardous waste;

(f) The most recent closure cost estimate;

(g) A description of the efforts undertaken during the year to reduce the volume and toxicity of waste generated;

(h) A description of the changes in volume and toxicity of waste actually achieved during the year in comparison to previous years to the extent such information is available for the years prior to 1984; and

(i) The certification signed by the owner or operator of FFP-LP or an authorized representative.

FFP-LP will not accept unmanifested hazardous waste from an off-site source. The requirements stated in 40 CFR 264.76 are not, therefore, applicable to this facility.

Additional reports required under 40 CFR 264.77(a) concerning releases, fires, and explosions are addressed in the Contingency Plan (Section G), and additional reports required under 264.77(b) concerning facility closures are addressed in the Closure Plan (Appendix I-1).

In accordance with 40 CFR 264.73(a), FFP-LP will keep a written operating record at the facility. The operating record will contain the following information, as required by 40 CFR 264.73(b):

1) Description and quantity of wastes received, along with method(s) and date(s) of treatment, storage or disposal, as outlined in 40 CFR 264 Appendix I;
2) Location of each waste at the facility and quantity at that location. This information will include reference to specific manifests;
3) All waste analysis results;
4) Detailed summaries of any incident requiring implementation of the Contingency Plan;
5) Inspection reports;
6) Monitoring, testing or analytical data, and corrective action where required by Subpart F and other Part 264 regulations;
7) Notices to generators, as specified in 264.12(b);
8) Closure cost estimates;
9) Waste minimization certification
10) Appropriate generator land disposal restriction notices in accordance with 40 CFR 268.7

The above information will be kept at the facility in the operating record until closure of the facility, with the exception of inspection records which will be retained for three years only (264.73(b)(5).

All records, including plans, required under 40 CFR 264 will be furnished upon request, and made available at all reasonable times for inspection, by any officer, employee, or representative of the Environmental

Protection Agency (EPA), who is duly designated by the Administrator; or equal representative from the Florida DER, who is duly designated by the Director; or similar representative from any local government (Polk County, local city governments), as required under 40 CFR 264.74(a).

Pursuant to 40 CFR 264.74(b), records will be retained for a period extended automatically during the course of any unresolved enforcement action regarding the facility or as requested by the Administrator.

EM ENgineering adVISORS, Inc.

2105 DUNDEE ROAD
POST OFFICE BOX 9309
WINTER HAVEN, FL 33883-9309
(813) 324-1112

CONSULTING CIVIL & ENVIRONMENTAL ENGINEERS, PLANNERS, AND ECONOMISTS

October 26, 1990

Mr. Ted Leigh, Managing Director
FIRST FLORIDA PROCESSING, L.P.
8150 Leesburg Pike
Suite 700
Vienna, VA 22182

Subject: 100 Year Floodplain Impacts

Project: First Florida Processing - Polk Co. Site

EVI Job Number: 905500.00

Dear Mr. Leigh:

In accordance with your request, we have made a preliminary analysis of the 100 year floodplains on First Florida Processing's (FFP) proposed development site.

Our review of the Federal Emergency Management Agency's (FEMA's) Flood Insurance Rate Map (FIRM) for the site shows that there are two isolated areas on the unimproved site that are classified as 'Zone A'. FEMA uses the 'Zone A' designation to indicate "Areas of 100-year flood; base flood elevations and flood hazard factors not determined." In layman's terms this means that areas designated 'Zone A' are areas which FEMA estimates will be impacted by a 100-year flood, but no detailed engineering studies were performed. Our experience in Polk County suggests that FEMA made 'Zone A' designations wherever swamp symbols appeared on a U.S.G.S. 7-1/2 minute topographic map.

The first of the two areas of 'Zone A' is located on the southern border of the property. It will not be affected by your proposed development plans. The second 'Zone A' area is located in the northern portion of the site. It is isolated and located totally within the property boundary. This area is within the portion of the site that will be developed.

We have reviewed the maps for the development site including the detailed topographic survey you provided to us. Our review indicates that the potential exists for stormwater to collect in the area designated 'Zone A' as the undeveloped site is presently graded. However, the surrounding topography would not allow ponding depths greater than 0.5 feet. Further, the flooded area is isolated. There does not appear to be any direct surface hydraulic connections between this area and any other surface water feature. Also, it does not appear that there are any surface water features which would discharge into this area.

Continued . . .

The development plans that you provided to us indicate that the site will be regraded and that all stormwater will be collected and treated on site and the design storm will be the 100 year storm. Development of the site would remove the low area and provide direct drainage of any low areas to the stormwater treatment area. This would remove the floodplain from the area of proposed development. Compensating storage would be provided by the stormwater infiltration pond. This would eliminate any hazards associated with the 100-year flood.

In summary, based on existing information it does not appear that there will be any hydrodynamic or hydrostatic impacts on your proposed development.

Part of our future work will include obtaining a revision to the FEMA FIRM 'Zone A' designation is based on site regrading and managing the 100 year storm onsite.

Please call us if you have any questions concerning this analysis.

Yours truly,
ENVISORS, INC.

Douglas M. Darden, P.E.
President

cc: Mr. Steve Rubin; EVI Job Files 905500.00; L01

SECTION C

WASTE CHARACTERISTICS

This section provides a general description of the chemical and physical characteristics of the hazardous waste accepted and managed at the Florida First Processing, L.P. (FFP-LP) facility, as well as the procedures used to analyze and identify the various waste streams. This section introduces the Waste Analysis Plan in Appendix C which describes in detail the reviews and analyses conducted to assure proper and safe management of wastes. This information is submitted in accordance with 40 CFR 270.14(b)(2) and F.A.C 17-730.220 and F.A.C 17-730.250.

C.1 CHEMICAL AND PHYSICAL CHARACTERIZATION

The facility will accept three broad "classes" or groupings of RCRA wastes and expects to receive several different types of waste constituents within each of these classes. The waste streams the facility will receive, primarily from Florida industries, are extremely varied in composition and quantity. The categorization scheme in Table C-1 groups these diverse wastes into three manageable classes which are organic, inorganic, and reactive wastes. Table C-2 lists examples of specific waste codes that fall into these classes. The three classes of wastes have been set up according to the characteristics that determine how each waste should be best managed. The organic wastes will be thermally treated in the incineration system. The inorganic wastes (i.e., wastes containing < 10% total RCRA-hazardous organics or < 1% RCRA-hazardous volatile organics) such as alkaline, acidic, chromate, and cyanide wastes which cannot be destroyed or rendered less hazardous by incineration will be conveyed to the inorganic treatment system. Inorganic

TABLE C-2

BREAKDOWN OF WASTE CODES BY CATEGORIES AND PROCESSING ALTERNATIVES

WASTE CATEGORY	WASTE CODES	PRIMARY PROCESS(ES)	SECONDARY PROCESS(ES)
Ignitable	D001	Incineration	
Wood Preservative	F032, F033, F034, F035, K001	Incineration	Inorganic Treatment
Organic Chemical Production	K009, K010, K011, K013, K014, K015, K016, K017, K018, K019, K020, K021, K022, K023, K024, K025, K026, K027, K028, K029, K030, K083, K085, K093, K094, K095, K096, K103, K104, K105, K111, K112, K113, K114, K115, K116, K117, K118, K136	Incineration	
Ink and Dye	K086, U023, U073, U191, U328, U353, U359	Incineration	Inorganic Treatment
Pesticide	D012, D013, D014, D015, D016, D017, K032, K033, K034, K035, K036, K037, K038, K040, K041, K042, K043, K097, K098, K099, P001, P003, P004, P018, P020, P034, P037, P045, P048, P049, P050, P051, P057, P059, P060, P070, P072, P088, P089, P092, P094, P097, P108, P111, P123, U009, U011, U036, U060, U061, U062, U115, U122, U125, U127, U142, U165, U244, U247	Incineration	Inorganic Treatment
Petroleum Refining	K048, K049, K050, K051, K052	Incineration	
Halogenated Solvent	F001, F002, F024, P016, P017, P023, P024, P026, P027, P028, P036, P095, P118, U005, U006, U017, U024, U025, U026, U027, U029, U030, U033, U034, U037, U039, U041	Incineration	Inorganic Treatment

TABLE C-2 (continued)

BREAKDOWN OF WASTE CODES BY CATEGORIES AND PROCESSING ALTERNATIVES

WASTE CATEGORY	WASTE CODES	PRIMARY PROCESS(ES)	SECONDARY PROCESS(ES)
Halogenated Solvent (continued)	~~U041~~, U042, U043, U044, U045, U046, U047, U048, U049, U058, U066, U067, U070, U071, U072, U074, U075, U076, U077, U078, U079, U080, U081, U082, U083, U084, U097, U121, U128, U129, U130, U131, U132, U150, U158, U183, U184, U185, U192, U207, U208, U209, U210, U211, U222, U225, U226, U227, U228, U235, U237, U243,	Incineration	Inorganic Treatment
Non-Halogenated Solvent	F003, F004, F005, P002, P005, P007, P008, P014, P015, P038, P042, P046, P054, P064, P067, P068, P069, P073, P077, P081, P082, P084, P085, P093, P102, P103, P110, P112, P116, U001, U002, U003, U004, U007, U010, U012, U014, U015, U016, U018, U019, U021, U022, U031, U050, U051, U053, U055, U056, U057, U059, U063, U064, U085, U086, U089, U090, U091, U092, U093, U094, U095, U096, U098, U099, U101, U105, U106, U108, U109, U110, U111, U116, U117, U120, U124, U126, U133, U137, U138, U140, U141, U146, U147, U148, U149, U152, U153, U154, U155, U157, U159, U160, U161, U163, U164, U166, U167, U168, U169, U170, U171, U172, U173, U174, U176, U177, U179, U180, U181, U182, U186, U187, U188, U190, U193, U194, U196, U197, U201,	Incineration	

TABLE C-2 (continued)

BREAKDOWN OF WASTE CODES BY CATEGORIES AND PROCESSING ALTERNATIVES

WASTE CATEGORY	WASTE CODES	PRIMARY PROCESS(ES)	SECONDARY PROCESS(ES)
Non-Halogenated Solvent (continued)	U203, U206, U213, U218, U219, U220, U221, U234, U239, etc.	Incineration	
Misc. Organic	K031, K039, K073, K084, K087, K101, K102, P009, P039, P040, P041, P043, P044, P047, P058, P062, P066, P071, P075, P101, P109, U008, U020, U035, U038, U052, U069, U087, U088, U102, U103, U107, U112, U113, U114, U118, U119, U123, ~~U136~~, U143, ~~U144~~, U156, U162, U178, U200, U202, U223, U236, U238, U240	Incineration	Inorganic Treatment
Corrosive	D002	Inorganic Treatment	
TCLP Metal	D004, D005, D006, D008, D009, D010, D011	Inorganic Treatment	
Cyanide	F012, P013, P021, P029, P030, P031, P033, P063, P064, P074, P098, P099, P101, P104, P106, P121, U246	Inorganic Treatment	
Chromium	D007, K002, K005, K006, K008, K086, K090, K091, U032	Inorganic Treatment	
Inorganic Chemical Production	K071, ~~K073~~, K084, K101, K102, K106	Inorganic Treatment	
Pigment	K003, K004, K007	Inorganic Treatment	Incineration
Metal Finishing/ Treatment	F006, F019, K060, K061, K062, K064, K065, K066, K069, ~~K087~~, K088, K100	Inorganic Treatment	

TABLE C-2 (continued)

BREAKDOWN OF WASTE CODES BY CATEGORIES AND PROCESSING ALTERNATIVES

WASTE CATEGORY	WASTE CODES	PRIMARY PROCESS(ES)	SECONDARY PROCESS(ES)
Acidic	K123, K124, K125, K126, P010, P058, P065, P114, P115, P119, U008, U028, U052, U123, U134, U136, U144, U145, U204, U214, U215, U217	Inorganic Treatment	
Alkaline	P047, P075, ~~U202~~, U248	Inorganic Treatment	
Reactive	D003	Inorganic Treatment	Incineration
Cyanide (Reactive)	F007, F008, F009, F010, F011, U223	Inorganic Treatment	
Misc. Inorganic	~~F028~~, K021, K028, P006, P011, P012, P022, P056, P076, P078, P087, P096, P105, P113, P120, P122, U068, U135, U151, U189, U205, U216, U249	Inorganic Treatment	Incineration ~~(except F028)~~

wastes containing RCRA-hazardous organic compounds will be blended to achieve an organic concentration of less than 100 mg/l before treatment. The reactive wastes will be tested to determine the best processing alternative.

Wastes from each class will be received in bulk shipments (e.g., tank trucks and railcars) or in containers (e.g., 55-gallon drums and container railcars). These shipments will consist of both pumpable and non-pumpable wastes in the form of liquids, sludges and solids.

The facility will not accept PCB wastes, radioactive wastes as regulated by the Nuclear Regulatory Commission, low level radioactive and hazardous mixed wastes that do not meet the requirements of 40 CFR 261.4(a)(4), explosive wastes, ignitable compressed gases, dioxin-containing wastes, ~~benzene at concentrations greater than or equal to ten percent,~~ pentachlorophenol except for K001 waste ~~as a waste constituent~~, or other wastes that the Plant Manager deems cannot be properly or safely managed. Shock-sensitive and air-reactive wastes may be accepted on a case-by-case basis only after extensive testing and evaluation. FFP-LP will also not accept any unmanifested waste from an off-site source.

The complete list of wastes to be processed at the facility is provided in Table C-3. "D" series wastes are characteristic wastes, "F" wastes are from non-specific sources, "K" wastes are from specific sources, "P" wastes are acutely hazardous commercial chemical products, and "U" wastes are toxic commercial chemical products.

According to 40 CFR 261.3(c)(2)(i), residues generated from the treatment, storage or disposal of the above listed wastes (except the D-listed wastes), including any sludge, spill residue, ash, emission control dust or leachate (but not including precipitation run-off), are hazardous wastes listed under the original waste codes from which they were derived, ~~even if they no longer exhibit the original characteristics~~ unless delisted. For instance, a solvent waste which has been processed to skim off the solvent, leaving behind the sludge precipitate, is listed under the original waste code even if the waste is no longer principally liquid. Other examples of wastes that will be accepted under their original waste codes are leachate collected from hazardous waste landfills which contains a dilute solution of certain listed waste constituents in water. ~~and process residuals from the off-site treatment of dioxin-containing wastes.~~

The waste categories and waste streams as delineated by Tables C-1 and C-2 are usually not unique; a waste can be both ignitable (D001) and from non-specific sources (e.g., F003). Moreover, there are almost countless combinations of waste constituents which can be mixed in any particular waste stream. A listing of all possible permutations of "D" and "F" wastes (which by themselves total 42) would result in 1.41 X 10^{51} entries. Such an extensive and inclusive list is not feasible, so only the individual principal waste constituents are listed in Table C-3 at the end of Section C.

Nevertheless, all wastes will be managed according to the safe and proper procedures described in the Waste Analysis Plan in Appendix C. The facility's operating record will include full documentation of the manifested wastes received and accepted. For example, an ignitable waste stream which is also TCLP because of its chromium concentration will be recorded as D001/D007. Such comprehensive designation of waste streams will result in appropriate storage and treatment alternatives.

C.2 WASTE ANALYSIS PLAN

The Waste Analysis Plan for the FFP-LP facility is provided in Appendix C. This plan describes the procedures that will be used to obtain the chemical and physical data to verify generator-provided information on the wastes' characteristics to ensure proper treatment and disposal. These procedures are related to pre-acceptance evaluation, sampling and analysis during waste receipt, analyses to determine optimum processing alternatives as well as analyses during and after process operations at the facility.

The responsibility for the implementation of the Waste Analysis Plan, as described in Appendix C, will lie with the facility's Environmental/Health and Safety Manager, in coordination with the General Engineer.

~~C.3 RECORDKEEPING REQUIREMENTS~~

~~If FFP-LP plans to receive hazardous wastes from a foreign source, it will notify the Regional Administrator in writing at least four weeks in advance of the date the waste is expected to arrive at FFP-LP, in accordance with 40 CFR 264.12(a).~~

~~As stated in 40 CFR 264.12(b), FFP-LP will inform in writing each generator that transports hazardous waste to the facility that the facility has the appropriate permit(s) for, and will accept, the waste the generator is shipping. FFP-LP will keep a copy of this written notice as part of its operating record.~~

~~Before transferring ownership or operation of the facility during its operating life, FFP-LP will notify the new owner or operator in writing of the requirements of 40 CFR 264 and 270, in accordance with 40 CFR 264.12(c) and F.A.C. 17-730 and the biennial report.~~

~~The requirements stated under 40 CFR 264.70 through 264.74 are addressed in Section 2.2, Waste Receipt Procedures, of the Waste Analysis Plan. As required under 40 CFR 264.75, FFP-LP will prepare and submit a single copy of a biennial report to the Regional Administrator by March 1 of each even numbered year. The biennial report will be submitted on EPA form 8700-13B. The report will cover facility activities during the previous calendar year and will include:~~

~~(a) The EPA identification number, name, and address of the facility;~~

~~(b) The calendar year covered by the report;~~

~~(c) The EPA identification number of each hazardous waste generator from which the facility received a hazardous waste during the year; for~~

imported shipments, the report will give the name and address of the foreign generator;

(d) A description and the quantity of each hazardous waste the facility received during the year. This information will be listed by EPA identification number of each generator;

(e) The method of treatment, storage, or disposal for each hazardous waste;

(f) The most recent closure cost estimate; and

(g) The certification signed by the owner or operator of FFP-LP or an authorized representative.

FFP-LP will not accept unmanifested hazardous waste from an off-site source. The requirements stated in 40 CFR 264.76 are not, therefore, applicable to this facility.

Additional reports required under 40 CFR 264.77(a) concerning releases, fires, and explosions are addressed in the Contingency Plan (Section G), and additional reports required under 264.77(b) concerning facility closures are addressed in the Closure Plan (Appendix I-1).

TABLE C-3 (continued)

WASTES TO BE ACCEPTED AT FLORIDA FIRST PROCESSING, INC.

U.S. EPA Hazardous Waste No.	Waste Description
Wastes from Non-Specific Sources (continued)	
F005	Spent non-halogenated solvents (and reclamation still bottoms): toluene, methyl ethyl ketone, carbon disulfide, isobutanol, pyridine, benzene, 2-ethoxyethanol, and 2-nitropropane (plus F001, F002, or F004) (I,T).
F006	Wastewater treatment sludges from electroplating, except from: sulfuric acid anodizing of aluminum; tin plating on carbon steel; zinc plating (segregated basis) on carbon steel; aluminum or zinc-aluminum plating on carbon steel; cleaning/stripping associated with tin, zinc and aluminum plating on carbon steel; chemical etching and milling of aluminum (T).
F007	Spent cyanide plating bath solutions from electroplating (R,T).
F008	Plating sludges - electroplating (using cyanides) (R,T).
F009	Spent stripping and cleaning bath solutions - electroplating (using cyanides) (R,T).
F010	Quenching oil bath residues - metal heat treating (using cyanides) (R,T)
F011	Spent cyanide solutions - salt bath pot cleaning in metal treating (R,T)
F012	Quenching wastewater treatment sludges - metal heat treating (using cyanides) (T).
F019	Wastewater treatment sludges - chemical conversion aluminum coating (T).
F024	Distillation residues, heavy ends, tars, reactor cleanout wastes, etc., from production of chlorinated aliphatic hydrocarbons, having carbon content from one to five, utilizing free radical catalyzed processes; does not include light ends, spent filters and filter aids, spent dessicants, wastewater, wastewater treatment sludges, spent catalysts, and wastes listed in 40 CFR 261.32 (T).
F025	Condensed light ends, spent filter and filter aids, and spent desiccant wastes from the production of chlorinated aliphatics

TABLE C-3 (continued)

WASTES TO BE ACCEPTED AT FLORIDA FIRST PROCESSING, INC.

U.S. EPA Hazardous Waste No.	Waste Description
Wastes from Non-Specific Sources (continued)	
F032*	Wastewaters, process residuals, preservative drippage, and discarded spent formulations from wood preserving processes at facilities that currently use or have previously used chlorophenolic formulations (except wastes from processes that have complied with cleaning or replacement procedures of 40 CFR 261.35 and do not resume or initiate use of chlorophenolic formulations); does not include K001 bottom sediment sludge from treatment of wastewater from wood preserving processes that use creosote and/or pentachlorophenol (T).
F033*	Wastewaters, process residuals, protectant drippage, and discarded spent formulations from wood surface protection processes at facilities that currently use or have previously used chlorophenolic formulations (except wastes from processes that have complied with cleaning or replacement procedures of 40 CFR 261.35 and do not resume or initiate use of chlorophenolic formulations) (T).
F034	Wastewaters, process residuals, preservative drippage, and discarded spent formulations from wood preserving processes using creosote formulations; does not include K001 bottom sediment sludge from treatment of wastewater from wood preserving processes that use creosote and/or pentachlorophenol (T).
F035	Wastewaters, process residuals, preservative drippage, and discarded spent formulations from wood preserving processes using inorganic preservatives containing arsenic or chromium; does not include K001 bottom sediment sludge from treatment of wastewater from wood preserving processes that use creosote and/or pentachlorophenol.
F039	Multi-source organic and inorganic leachate.
Wastes from Specific Sources	
K001	Bottom sediment sludge from the treatment of wastewaters from wood-preserving processes that use creosote and/or pentachlorophenol.
K002	Wastewater treatment sludge - chrome yellow & orange pigment production
K003	Wastewater treatment sludge - molybdate orange pigment production.
K004	Wastewater treatment sludge - zinc yellow pigment production.
K005	Wastewater treatment sludge - chrome green pigment production.
K006	Wastewater treatment sludge - chrome oxide green pigment production (anhydrous & hydrated).
K007	Wastewater treatment sludge - iron blue pigment production.

*These waste codes may include pentachlorophenol as one possible constituent. The facility will only accept wastes classified under these codes which do not contain pentachlorophenol.

TABLE C-3 (continued)

WASTES TO BE ACCEPTED AT FLORIDA FIRST PROCESSING, INC.

U.S. EPA Hazardous Waste No.	Waste Description
Toxic Wastes (continued)	
U162	Methyl methacrylate / 2-Propenoic acid, 2-methyl-, methyl ester (I,T).
U163	N-Methyl-N'-nitro-N-nitrosoguanidine (MNNG).
U164	Methylthiouracil / 4(1H)-Pyrimidinone, 2,3-dihydro-6-methyl-2-thioxo-.
U165	Naphthalene.
U166	1,4-Naphthalenedione / 1,4-Naphthoquinone.
U167	1-Naphthalenamine / alpha-Naphthylamine.
U168	2-Naphthalenamine / beta-Naphthylamine.
U169	Nitrobenzene (I,T).
U170	p-Nitrophenol / Phenol, 4-nitro-.
U171	2-Nitropropane (I,T).
U172	N-Nitrosodi-n-butylamine / 1-Butanamine, N-butyl-N-nitroso-.
U173	N-Nitrosodiethanolamine / Ethanol, 2,2'-(nitrosoimino)bis-.
U174	N-Nitrosodiethylamine / Ethanamine, N-ethyl-N-nitroso-.
U176	N-Nitroso-N-ethylurea.
U177	N-Nitroso-N-methylurea.
U178	N-Nitroso-N-methylurethane / Carbamic acid, methylnitroso-, ethyl ester.
U179	N-Nitrosopiperidine / Piperidine, 1-nitroso-.
U180	N-Nitrosopyrrolidine / Pyrrolidine, 1-nitroso-.
U181	5-Nitro-o-toluidine / Benzenamine, 2-methyl-5-nitro-.
U182	Paraldehyde / 1,3,5-Trioxane, 2,4,6-trimethyl-.
U183	Pentachlorobenzene.
U184	Pentachloroethane.
U185	Pentachloronitrobenzene (PCNB).
U186	1,3-Pentadiene / 1-Methylbutadiene (I).
U187	Phenacetin / Acetamide, N-(4-ethoxyphenyl)-.
U188	Phenol.
U189	Phosphorus sulfide / Sulfur phosphide (R).
U190	Phthalic anhydride / 1,3-Isobenzofurandione.
U191	2-Picoline / Pyridine, 2-methyl-.
U192	Pronamide / Benzamide, 3,5-dichloro-N-(1,1-dimethyl-2-propynyl)-.
U193	1,3-Propane sultone / 1,2-Oxathiolane, 2,2-dioxide.
U194	n-Propylamine / 1-Propanamine (I,T).
U196	Pyridine.
U197	p-Benzoquinone / 2,5-Cyclohexadiene-1,4-dione.
U200	Reserpine / Yohimban-16-carboxylic acid, 11,17-dimethoxy-18-[(3,4,5-trimethoxybenzoyl)oxy]-, methyl ester, (3beta,16beta,17alpha,18beta,20alpha)-.
U201	Resorcinol / 1,3-Benzenediol.
U202	Saccharin / 1,2-Benzisothiazol-3-(2H)-one, 1,1-dioxide; and salts.
U203	Safrole / 1,3-Benzodioxole, 5-(2-propenyl)-.
U204	Selenious acid / Selenium dioxide.
U205	Selenium sulfide / Sulfur selenide, SeS_2 (R,T).
U206	Streptozotocin / D-Glucopyranose, 2-deoxy-2(3-methyl-3-nitrosoureido)- / D-Glucose, 2-deoxy-2[[(methylnitrosoamino)-carbonyl]amino]-.

WASTES TO BE ACCEPTED AT FLORIDA FIRST PROCESSING, INC.

U.S. EPA Hazardous Waste No.	Waste Description
Toxic Wastes (continued)	
U207	1,2,4,5-Tetrachlorobenzene.
U208	1,1,1,2-Tetrachloroethane.
U209	1,1,2,2-Tetrachloroethane.
U210	Tetrachloroethylene / Ethene, tetrachloro-.
U211	Carbon tetrachloride / Methane, tetrachloro-.
U213	Tetrahydrofuran (I).
U214	Thallium(I) acetate / Acetic acid, thallium(1+) salt.
U215	Thallium(I) carbonate / Carbonic acid, dithallium(1+) salt.
U216	Thallium(I) chloride, TlCl.
U217	Thallium(I) nitrate / Nitric acid, thallium(1+) salt.
U218	Thioacetamide / Ethanethioamide.
U219	Thiourea.
U220	Toluene / Benzene, methyl-.
U221	Toluenediamine / Benzenediamine, ar-methyl-.
U222	o-Toluidine hydrochloride / Benzenamine, 2-methyl-, hydrochloride.
U223	Toluene diisocyanate / Benzene, 1,3-diisocyanatomethyl- (R,T).
U225	Bromoform / Methane, tribromo-.
U226	1,1,1-Trichloroethane / Methyl chloroform.
U227	1,1,2-Trichloroethane.
U228	Trichloroethylene / Ethene, trichloro-.
U234	1,3,5-Trinitrobenzene (R,T).
U235	Tris (2,3-dibromopropyl) phosphate.
U236	Trypan blue / 2,7-Naphthalenedisulfonic acid, 3,3'-[(3,3'-dimethyl-(1,1'-biphenyl)-4,4'-diyl)]bis(azo)bis(5-amino-4-hydroxy)-, tetrasodium salt.
U237	Uracil mustard / 2,4-(1H,3H)-Pyrimidinedione, 5-[bis(2-chloroethyl)amino]-.
U238	Ethyl carbamate (urethane) / Carbamic acid, ethyl ester.
U239	Xylene / Benzene, dimethyl- (I,T).
U240	2,4-D / 2,4-Dichlorophenoxyacetic acid, salts and esters.
U243	Hexachloropropene / 1-Propene, 1,1,2,3,3,3-hexachloro-.
U244	Thiram / Thioperoxydicarbonic diamide, tetramethyl-, $[(H_2N)C(S)]_2S_2$.
U246	Cyanogen bromide, (CN)Br.
U247	Methoxychlor / Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-methoxy-.
U248	Warfarin / 2H-1-Benzopyran-2-one, 4-hydroxy-3-(3-oxo-1-phenylbutyl)-; and salts, when present at concentrations of 0.3% or less.
U249	Zinc phosphide, Zn_3P_2, when present at concentrations of 10% or less.
U328	o-Toluidine / Benzenamine, 2-methyl-.
U353	p-Toluidine / Benzenamine, 4-methyl-.
U359	2-Ethoxyethanol / Ethylene glycol monoethyl ether.

Key: I = Ignitable; L=Toxicity Characteristics Leaching Procedure; C = Corrosive; H = Acutely Hazardous; R = Reactive; T = Toxic

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2.0 PRE-ACCEPTANCE AND RECEIPT PROCEDURES

Pre-acceptance and receipt procedures are important components of waste management at the Florida First Processing, L.P. facility. Pre-acceptance procedures are employed to determine whether a waste to be received from a generator is amenable to ~~the thermal~~ incineration and/or inorganic treatment at the facility and whether the waste can be safely and effectively handled and stored at the facility.

Receipt control procedures are employed to determine whether waste received at the facility is the same waste approved under the pre-acceptance procedures, and to identify characteristics of the waste in order to determine how it should be stored and handled.

2.1 PRE-ACCEPTANCE PROCEDURES

Before a generator is authorized to ship a waste to the facility, that waste must be approved by FFP-LP under the pre-acceptance procedures. To initiate these procedures, the generator is required to complete and submit a Pre-Acceptance Waste Characterization Sheet (see Figure 2-1) to fully describe the waste in accordance with 40 CFR 264.13(b)(5). On the last page of the Pre-Acceptance Waste Characterization Sheet, the generator must identify if the waste contains any of the listed 21 toxic constituents. If any of the constituents of concern are present, then the waste will be analyzed prior to acceptance to the facility to determine if it contains "significant amounts" of the noted toxic constituent(s) (see Section 4.1).

The generator is required to submit a representative sample of the waste and a Notification for Land Disposal-Restricted Wastes if the waste is one that is restricted for land disposal by 40 CFR 268 Subpart C. This notification, which includes information on any applicable prohibitions and the appropriate treatment standards related to the best demonstrated and available technologies (BDAT) set forth in 40 CFR 268 Subpart C and Subpart D respectively, must also be submitted with each waste shipment, as required by 40 CFR 268.7. The notification serves a recordkeeping function. All wastes accepted and residues generated on-site are handled and disposed as land ban wastes.

2.1.1 Screening Procedures for "Problem" Air Toxics Compounds

To ensure that FFP-LP operations do not result in any fugitive emissions of compounds which may exceed Florida's draft air toxic guidelines, FFP-LP will use a screening procedure to identify the presence, and appropriate management, of any wastes containing such compounds. The 61 organic compounds for which this screening procedure will be used are listed in Table 2-1.

The initial step in identifying the presence of any of the 61 air toxic compounds will be to review the pre-acceptance waste characterization form to determine whether specific air toxic chemicals are listed as components of the waste. For any of the 61 air toxic compounds listed on the waste characterization form, a comparison of the specified concentration with precalculated limits will be performed to determine if the waste shipment could result in fugitive emissions of concern. Subsequently, special handling procedures will be specified to avoid exceedences of the air toxic guidelines.

In order to determine the likelihood that one of the 61 air toxic chemicals is present in a waste shipment but not explicitly identified on the waste characterization form, an industry-specific checklist will be used in screening all waste shipments to determine which generators are likely to send wastes to the facility containing any of the 61 air toxic compounds.

Generators whose wastes are suspected of containing any of the 61 air toxic compounds will be contacted for further information concerning specific waste components. Based on the generator's response, the fingerprint analysis and any other chemical analysis deemed necessary by FFP-LP, the waste shipment may be set aside for special handling and disposal.

TABLE 2-1

"No Threat Levels" for Florida Air Toxic Chemicals of Concern
As Fugitive Emissions (ug/m^3)

new #	CLASS A's	COMPOUND	8-HR	24-HOUR	ANNUAL	CEILING (ONE-HR)	VP (mmHg)
		Modeled impacts for chemical in 100% of storage (ug/m^3)	25.6	14.2	3.1	70.8	
1		Ethanethiol (ethyl mercaptan)	10	2.4	--		437
2	*	Dichloromethane (methylene chloride)	--	--	3		382
3		1,1-Dichloroethylene (vinylidene chloride)	--	--	0.02		222
4		Acrolein	2.5	0.60	--		214
5		1,2-Dichloroethane (ethylene dichloride)	40	9.5	0.04		182
6		Ethylidene chloride (1,1-dichloroethane)	4000	952	0.04		182
7		2-Chloro-1,3-butadiene (b-chloroprene)	--	--	3		179
8		Ethylenimine	10	2.4	--		160
9	*	Trichloromethane (chloroform)	--	--	0.04		160
10	*	1,1-Dimethylhydrazine	0.25	0.060	--		157
11		Propylene Imine	50	12	--		112
12		1,3-Dichloropropene	--	--	3E-06		109
13	*	Chloromethyl methyl ether	--	--	0.0004		107
[illegible]		Chloroacetaldehyde	(a)	(a)	(a)	30	100
15		Thionyl chloride	(a)	(a)	(a)	5	100
16		Carbonyl chloride (phosgene)	4.0	0.95	--		91
17	*	Tetrachloromethane (carbon tetrachloride)	--	--	0.07		91
18	*	Vinyl cyanide (acrylonitrile)	--	--	0.0150		86
19		Aldicarb	--	--	1		83
20	*	Benzene	--	--	0.12		75
21		Perchloromethyl mercaptan	8	1.9	--		65
22		Trichloroethylene	--	--	0.77		58
23		Methylacrylonitrile (methacrylonitrile)	--	--	0.10		57
24	*	Methyl hydrazine	0.11	0.070	0.07		50
25		Chloral	--	--	2		40
26		1,1,2,2-Tetrachloroethane	70	17	0.02		40
27		Butyl mercaptan	15	3.6	--		35
28		Bis(chloromethyl)ether	--	--	0.00002		30
29		Crotonaldehyde	60	14	--		30
30		Dioxane, 1,4-	--	--	0.70		29
31		Dioxathion	2.0	0.50	--		29
32		Glycidyaldehyde	--	--	0.30		27
33	*	Hexachlorobutadiene	2.4	0.60	0.05		22
34		Tetramethyl lead as Pb	0.75	0.18	--		22
35		Chloroacetyl chloride	2.3	0.50	--		20
36		Chloropicrin (nitrotrichloromethane)	7	1.7	--		20
37		Glutaraldehyde	(a)	(a)	(a)	8	17
38	*	2-Nitropropane	--	--	0.00004		13
39		Propargyl alcohol	20	4.8	--		11
[illegible]	*	1,2-Dibromoethane (ethylene dibromide)	--	--	0.0046		11

TABLE 2-1
(continued)

"No Threat Levels" for Florida Air Toxic Chemicals of Concern
As Fugitive Emissions (ug/m^3)

			25.6	14.2	3.1	70.8		1,2,3
		COMPOUND	8-HR	24-HOUR	ANNUAL	CEILING (ONE-HR)	VP (mmHg)	S,L,G (PHASE)
41		1-Chloro-2,3-epoxy-propane (epichlorohydrin)	--	--	0.30		10	
42	*	Hydrazine	--	--	0.0003		10	
43		Thioglycolic acid	40	9.5	--		10	
44		Diethylene triamine	40	9.5	--		7.6	
45		2-Methylcyclopentadienyl manganese tricarbonyl as	2.0	0.50	--		7.3	
46		Isophorone diisocyanate	0.45	0.10	--		6.0	
47		Bromoform	50	12	--		5.0	
48		2-Chloroethanol (ethylene chlorohydrin)	(a)	(a)	(a)	30	5.0	
49		2,2-Dichloropropionic acid	60	14	--		5.0	
50		Methyl Isocyanate	0.50	0.12	--		3.8	
51	*	beta-Propiolactone	15	3.6	--		3.4	
52	*	Dimethylnitrosamine (N-nitrosodimethylamine)	--	--	0.00007		2.7	
53	*	Dimethyl carbamoyl chloride	(a)	(a)	(a)		2.0	
54		1,2-Diphenylhydrazine	--	--	0.0040		1.8	
55		Phenyl mercaptan	20	4.8	--		1.1	
56		tert-Butyl chromate	(a)	(a)	(a)	1		2
57		2-Chloropropionic acid	4.4	1.0	--			2
58		Dichloroacetylene	(a)	(a)	(a)	4		2
59		2-Hydroxypropyl acrylate	30	7.0	--			2
60		Methyl ethyl ketone peroxide	(a)	(a)	(a)	50		2
61		Methyl silicate	60	14	--			2

Figure 2-1

FLORIDA FIRST PROCESSING FACILITY
PRE-ACCEPTANCE WASTE CHARACTERIZATION SHEET

Sheet Reference Number ☐☐☐☐☐

GENERATOR

Name: ____________________

Address:

Facility ____________________

____

Billing ____________________

____

Contact:

Technical __________ Phone __________

Business __________ Phone __________

U.S. EPA ID No: ____________________

REPRESENTATIVE SAMPLE

Customer Sample No.: ____________________

Sample Collection Date: ____________________

Sampling Method: ____________________

U.S. EPA Waste No(s): ____________________

Waste Name/Description: ____________________

Generating Process: ____________________

PHYSICAL DESCRIPTION

Physical State @25°C		Color	pH	%Separate Phase Water	Solids Dissolved	Melting Point	Heat Value
		______	______	______	______%	______°C	
☐ Solid	☐ Single Phased	Odor	TOC				______
☐ Slurry	☐ Bi-Layered	______	______mg/l	Specific Gravity	Suspended	Boiling Point	BTU/lb
☐ Liquid	☐ Multiphased	☐ None		______	______%	______°C	

WASTE COMPOSITION

ORGANICS			METALS			INORGANICS		
______	______	%	Arsenic (As)	______	ppm	Ash	______	%wt
______	______	%	Barium (Ba)	______	ppm	Bromine (Br)	______	%wt
______	______	%	Beryllium (Be)	______	ppm	Chloride (Cl)	______	%wt
______	______	%	Cadmium (Cd)	______	ppm	Cyanide (Cn)	______	%wt
______	______	%	Chromium (Cr)	______	ppm	Flourine (F)	______	%wt
______	______	%	Lead (Pb)	______	ppm	Iodine (I)	______	%wt
______	______	%	Mercury (Hg)	______	ppm	Nitrogen (N)	______	%wt
______	______	%	Nickel (Ni)	______	ppm	Phosphorous (P)	______	%wt
______	______	%	Selenium (Se)	______	ppm	Sulfer (S)	______	%wt
______	______	%	Silver (Ag)	______	ppm	______	______	%wt
______	______	%	Zinc (Zn)	______	ppm	______	______	%wt
TOTAL	100	%	______	______	ppm	______	______	%wt
			______	______	ppm	______	______	%wt

Figure 2-1 (Cont.)

NOTE:

Florida First Processing, L.P.. will NOT accept in any form: Pentachlorophenol production wastes, PCB Wastes, Dioxin and Furan Wastes, Radioactive Wastes, Explosives, Compressed Gases, Or Medical Wastes.

ADDITIONAL INFORMATION

TEST METHODS (for data on this sheet)

____

____

____

CONTENTS

☐ PCBs > 50 ppm ☐ Phenols ☐ Sulfides ☐ Toxic Constituents (see next page)

PROPERTIES

☐ Radioactive ☐ Explosive ☐ Shock-Sensitive ☐ Infectious

☐ Reactive with ______________________________

☐ Incompatible with ______________________________

CONTAINER HANDLING ☐ N/A

Is there a Dusting Hazard if Containers are Opened? ______________________________

Can Wastes Be Pumped? __________ Poured? __________ Vapor Pressure __________@__________°C

Percentage Free Flowing __________% Volume

Storage Method______________________________ Flash Point __________°C

Special Handling Procedures ______________________________

VOLUME (TONS)

Annual __________ This Request__________ Per Shipment __________

FREQUENCY

☐ Week ☐ Month ☐ Quarter ☐ Year ☐ One Time ☐ Other

SHIPPING

DOT Shipping Name__________ DOT Hazard Classification__________ UN/NA No. __________

DOT Placard__________ DOT Label__________

Bulk__________ gallons DOT Spec__________

Container Size	Material of Construction	DOT Spec	Weight Per Container	Container Label

LAND BAN NOTIFICATION ☐ N/A

EPA Hazardous Waste Numbers	Applicable Prohibitions (40 CFR 268 Subpart C)	Treatment Standards (40 CFR 268 Subpard D)

Attach Detailed Analysis

Figure 2-1 (Cont.)

SPECIFIC TOXIC CONSTITUENTS

	YES/NO	Corrective Action Level Concentrations (%)	Approximate Concentration (ppm)
1. Aldrin		2.9	
2. Benzidine		0.2	
3. Bis (chloroethyl) ether		44.0	
4. Chlordane		37.1	
5. Dibutyinitrosoamine		8.9	
6. Dieldrin		3.0	
7. Diethylnitrosoamine		0.3	
8. Dimethyinitrosoamine		0.9	
9. 1,2 Diphenylhydrazine		60.0	
10. Ethylene Dibromide		63.3	
11. Heptachlor		10.7	
12. Heptachlor Epoxide		5.2	
13. Hexachlorobenzene		28.9	
14. a-Hexachlorocyclohexane		7.7	
15. Hydrazine		4.8	
16. N-nitroso-N-Methylethylamine		2.2	
17. N-nitroso-N-propylamine		6.8	
18. N-nitroso-N-diethanolamine		17.9	
19. N-nitrosopyrolidine		23.4	
20. Thiourea		24.7	
21. Toxaphene		44.0	

CERTIFICATION

I certify under penalty of law that I personally have examined and am familiar with the waste through analysis and testing or through knowledge of the waste to support this certification that the waste complies with the treatment standards specified in 40 CFR Part 268 Subpart D and all applicable prohibitions set forth in 40 CFR 268.32 or RCRA section 3004(d). I believe that the information I submitted is true, accurate and complete. I am aware that there are significant penalties for submitting a false certification, including the possibility of a fine and imprisonment.

Signature	Title
Name	Date

2.2 WASTE RECEIPT PROCEDURES

When a shipment of waste arrives at the facility, the manifest accompanying the shipment is reviewed for completeness and for accuracy with respect to the weight (bulk wastes) or quantity (containerized wastes) of wastes on the shipment. The purpose of these routine checks is to ensure that the information on the manifest is accurate, to confirm that the wastes are those identified in the pre-acceptance information, and to optionally determine the compatibility or treatability characteristics for storage and processing. The condition of the transporting vehicles, e.g. the tank trucks and railroad tank cars, will also be inspected to ensure that the vehicles will safely contain the waste shipment while within the facility. This inspection can additionally reveal any problems such as leaking containers within the vehicles which can promptly be corrected. The inspection and analytical procedures are designed to meet the requirements of 40 CFR 264.13(c).

For bulk shipments, the tank trucks or railroad tank cars are weighed at the unloading stations to obtain the net weight of the bulk wastes (total weight minus tare weight of tank truck/railroad tank cars). A paper review of the manifest is conducted for agreement between pre-acceptance information and the determined weight, within ten percent variation, as stated in 40 CFR 264.72(a). Accurate manifests are signed and dated in accordance with 40 CFR 264.71, and any significant discrepancies in the manifest will be noted on each copy of the manifest. A copy is then given to the transporter. A representative sample of the bulk shipment is collected using the equipment and procedures outlined in Section 3.1.1. Section 3.1.1.1 identifies the proper equipment to be used (Table 3-1) and procedures for its use while Section 3.1.1.3 describes sampling procedures for various waste containers. The trucks or railroad tank cars are then parked or immobilized while waiting for the results of the waste receipt laboratory analyses. The sample is analyzed at least for fingerprint characteristics. Treatability tests may be conducted at this time if a short turn-around of results is not required. Compatibility tests designed to take the precautions required by 40 CFR 264.17 to prevent adverse reactions may be conducted especially if tank storage rather than direct burning is the management option assigned to the shipment.

Standard waste compatibility tables such as the one provided in Figure 2-2 may be consulted for reference.

For containerized waste, the manifest is first compared against the pre-acceptance papers. Accurately manifested containers are unloaded into a container staging area where a count and waste code check is conducted for accuracy with respect to the manifest. If these checks are complete and affirmative, a copy of the signed and dated manifest is given to the transporter, and the container truck is allowed to leave the facility. Ten percent of the total shipment is sampled and analyzed for fingerprint characteristics. Representative samples are collected by implementing procedures outlined in Section 3.1.1. Specific procedures for sampling ten (10) percent of containerized waste shipments are described in Section 3.1.1.3, using Table 3-3, Random Sampling. Compatibility and treatability/processing tests may be conducted for additional information, if applicable. The analytical results are checked for confirmation of the pre-acceptance waste characterization. If there is significant deviation - analytical results which would change the classification and/or treatment scenario of the waste - 100% sampling is to be conducted on that shipment. These differences include organic vs inorganic, change in waste code, or identification of additional waste constituents.

In accordance with regulations concerning manifesting in 40 CFR 264 Subpart E, any discrepancy is first discussed with the generator. If the waste is acceptable and treatable in spite of minor discrepancies, a re-characterization of the waste is requested from the generator. Alternatively, the shipment is to be rejected and returned to the generator if the discrepancy cannot be resolved within 15 days after receipt. A manifest discrepancy report describing the discrepancy and attempts to reconcile it is filed with the Florida Department of Environmental Regulation and a copy sent to the generator in accordance with 40 CFR 264.72(b).

The waste shipment is also inspected for leaks or other packaging problems. If a problem is identified, the facility office is notified and appropriate measures are taken to correct, clean-up, and if necessary, return the waste to the generator.

If the waste is acceptable based upon the shipment information and sample results, the receipt is approved by signing the manifest and unloading the waste into storage tanks or directly into the treatment units at the facility. In accordance with 40 CFR 264.71, a copy of the manifest is given or sent to the transporter, and another copy is sent to the generator within thirty days of delivery. A copy of the manifest will also be retained in the operating record of the facility for at least three years from the date of the waste receipt.

~~In accordance with 40 CFR 264.73(a), FFP-LP will keep a written operating record at the facility. All records, including plans, required under 40 CFR will be furnished upon request, and made available at all reasonable times for inspection, by any officer, employee, of representative of Florida DER who is duly designated by the Director, as required under 40 CFR 264.74(a)~~.

FFP-LP reserves the right to reject and return a shipment to the generator if, based on information or analyses obtained at any time, the waste significantly differs from what was purported to have been shipped. This may occur even after approval of the waste shipment and release of the transporter.

A decision logic diagram which describes pre-acceptance characterization, contractual agreement, and receipt control procedures is shown on Figure 2-3.

[Section 3.0 has been revised in its entirety]

3.0 SAMPLING AND SAMPLE HANDLING

The Florida First Processing, Inc. facility uses standard EPA procedures for sampling hazardous waste and handling samples of that waste. These wastes are identified by the generator in pre-acceptance procedures using the definitions in 40 CFR 261, to be:

- A characteristic hazardous waste; or
- A listed hazardous waste; or
- A solid waste which is not a hazardous waste.

3.1 SAMPLING EQUIPMENT AND PROCEDURES

Equipment and procedures used for waste receipt and process/residual line sampling are discussed in this section. Sampling for pre-acceptance waste characterization is not included as the waste generator supplies the sample.

3.1.1 Sampling for Waste Receipt Analysis

Representative samples for waste receipt analysis are collected by selecting appropriate sampling equipment; sample numbers, locations, and volumes; and sampling procedures based on the physical state of the waste and type of container.

3.1.1.1 Sampling Equipment

Table 3-1 presents examples of sampling equipment for various waste and container types. These samplers are illustrated in Figure 3-1 and described below along with procedures for use (Ref. a, b, c).

TABLE 3-1

RECOMMENDED SAMPLING EQUIPMENT

WASTE TYPE	CONTAINER	WASTESAMPLING EQUIPMENT
Liquids and slurries	Drum	Coliwasa Weighted bottle
	Closed-bed truck	Coliwasa
	Tank trucks and rail tank cars	Coliwasa
	Storage tanks and bins	Weighted bottle
	Pipe	Dipper
Sludge	Drum	Trier
	Open-bed truck	Trier
	Closed-bed truck	Trier
	Tank trucks	Coliwasa
Moist powders and granules	Drum	Trier
	Sacks and bags	Trier
	Open-bed truck	Trier
	Closed-bed truck	Trier
	Storage tanks and bins	Trier
	Conveyor belt	Scoop Shovel
Dry powders and granules	Drum	Thief
	Sacks and bags	Thief
	Open-bed truck	Thief

TABLE 3-1 (continued)

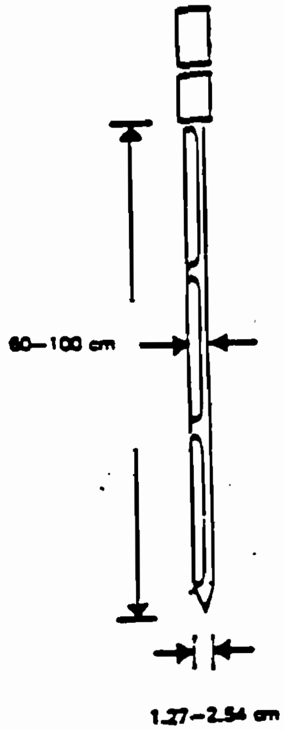
RECOMMENDED SAMPLING EQUIPMENT

WASTE TYPE	WASTE CONTAINER	SAMPLING EQUIPMENT
	Closed-bed truck	Thief
	Conveyor belt	Scoop Shovel
	Pipe	Dipper
Sand, packed powders,and granules	Drum	Auger
	Sacks and bags	Auger
	Open-bed truck	Auger
	Closed-bed truck	Auger
	Storage tanks and bins	Thief
	Conveyer belt	Dipper
	Pipe	Dipper
Large grained solids	Drum	Large trier
	Sacks and bags	Large trier
	Open-bed truck	Large trier
	Closed-bed truck	Large trier
	Storage tanks and bins	Large trier
	Conveyor belt	Trier
	Pipe	Dipper

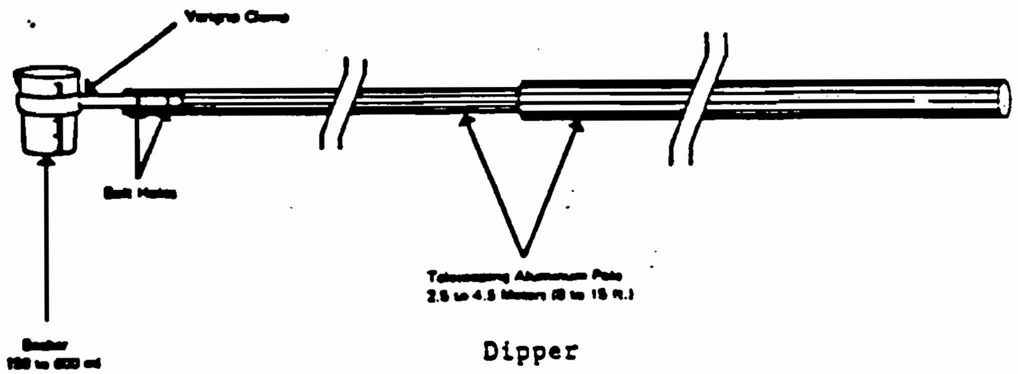
(Source: Ref. d, e, f)

FIGURE 3-1

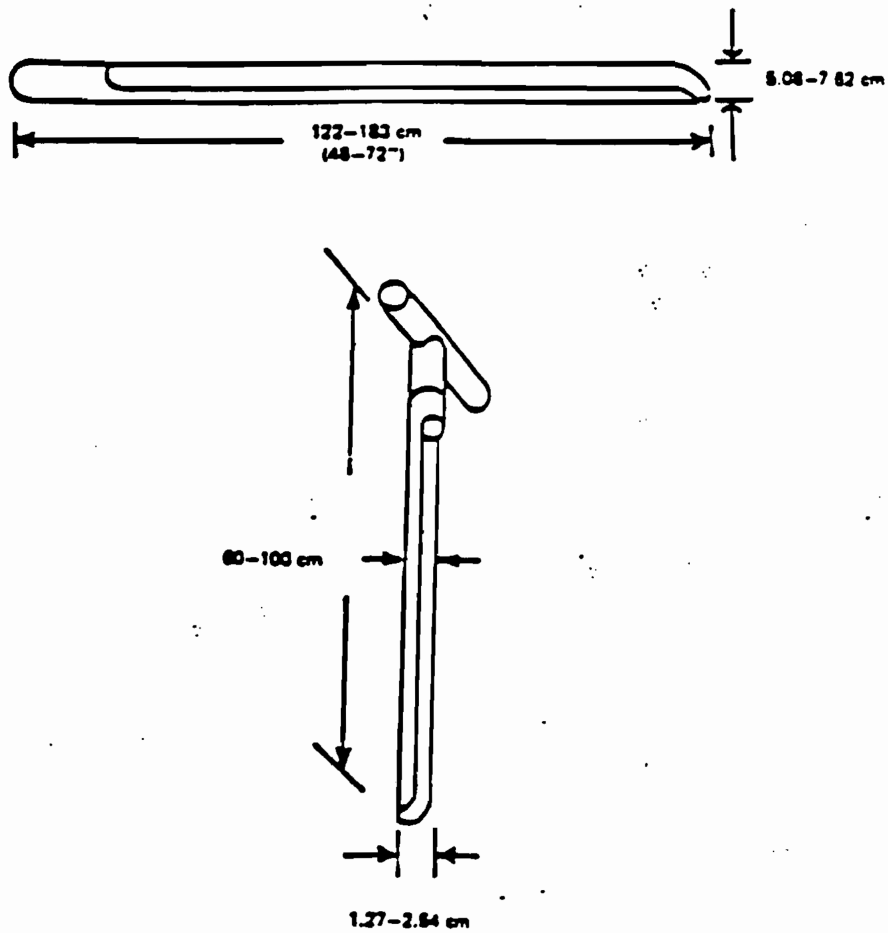
SAMPLERS



Thief



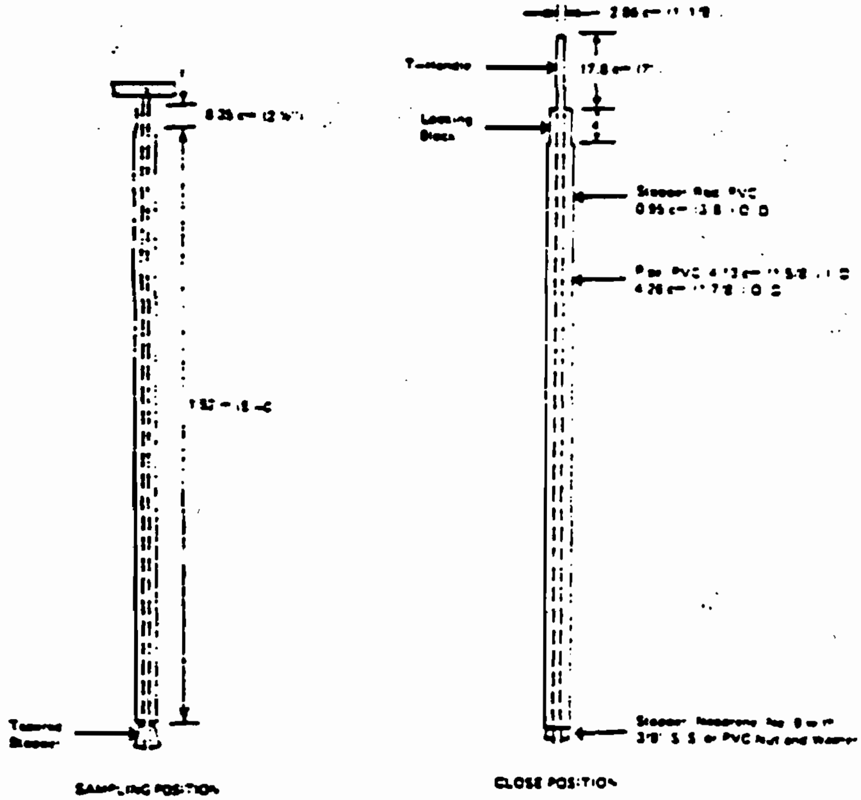
Dipper



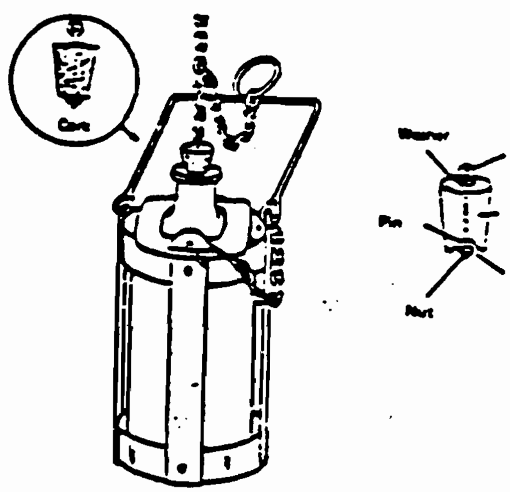
Triers

FIGURE 3-1 (continued)

SAMPLERS



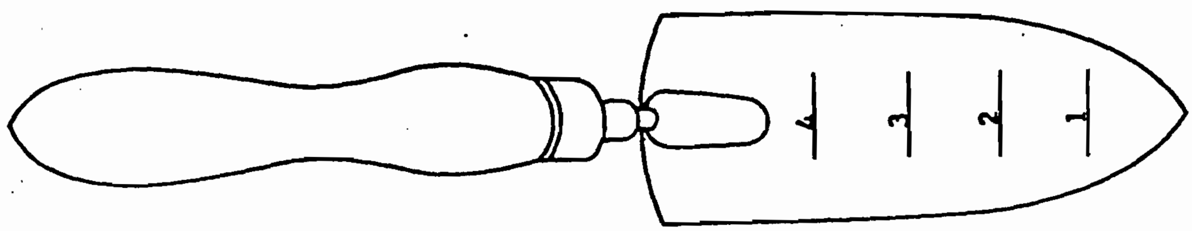
Coliwasa



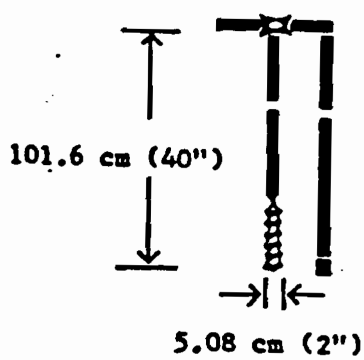
Weighted Bottle

FIGURE 3-1 (continued)

SAMPLERS



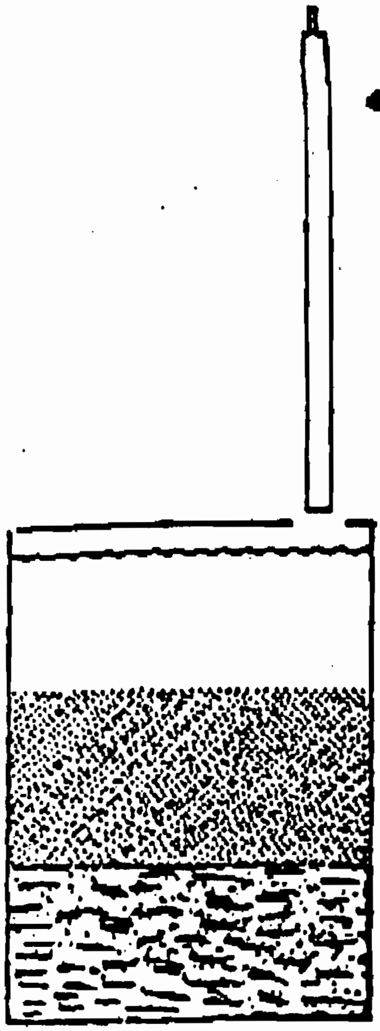
scoop with calibrations



auger

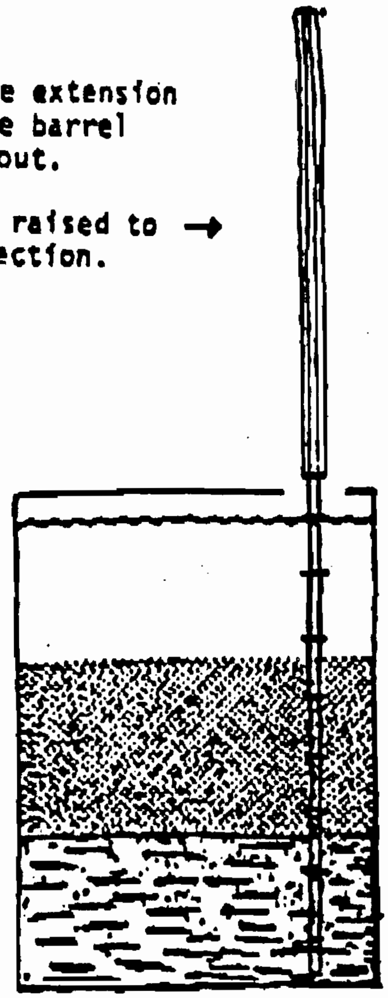
WAP 12e

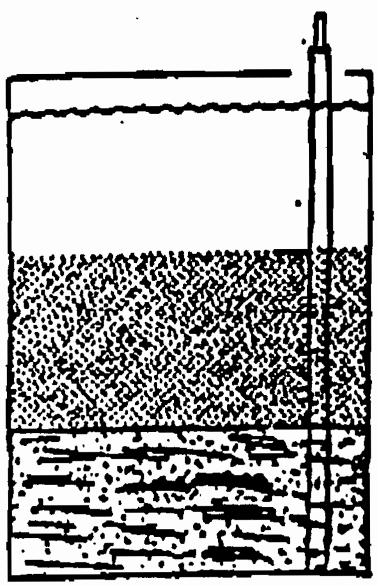
STRATIFIED SAMPLE THIEF



← A. The sampler with the extension rod is placed in the barrel through the pour spout.

B. The outer sheath is raised to expose the center section. →



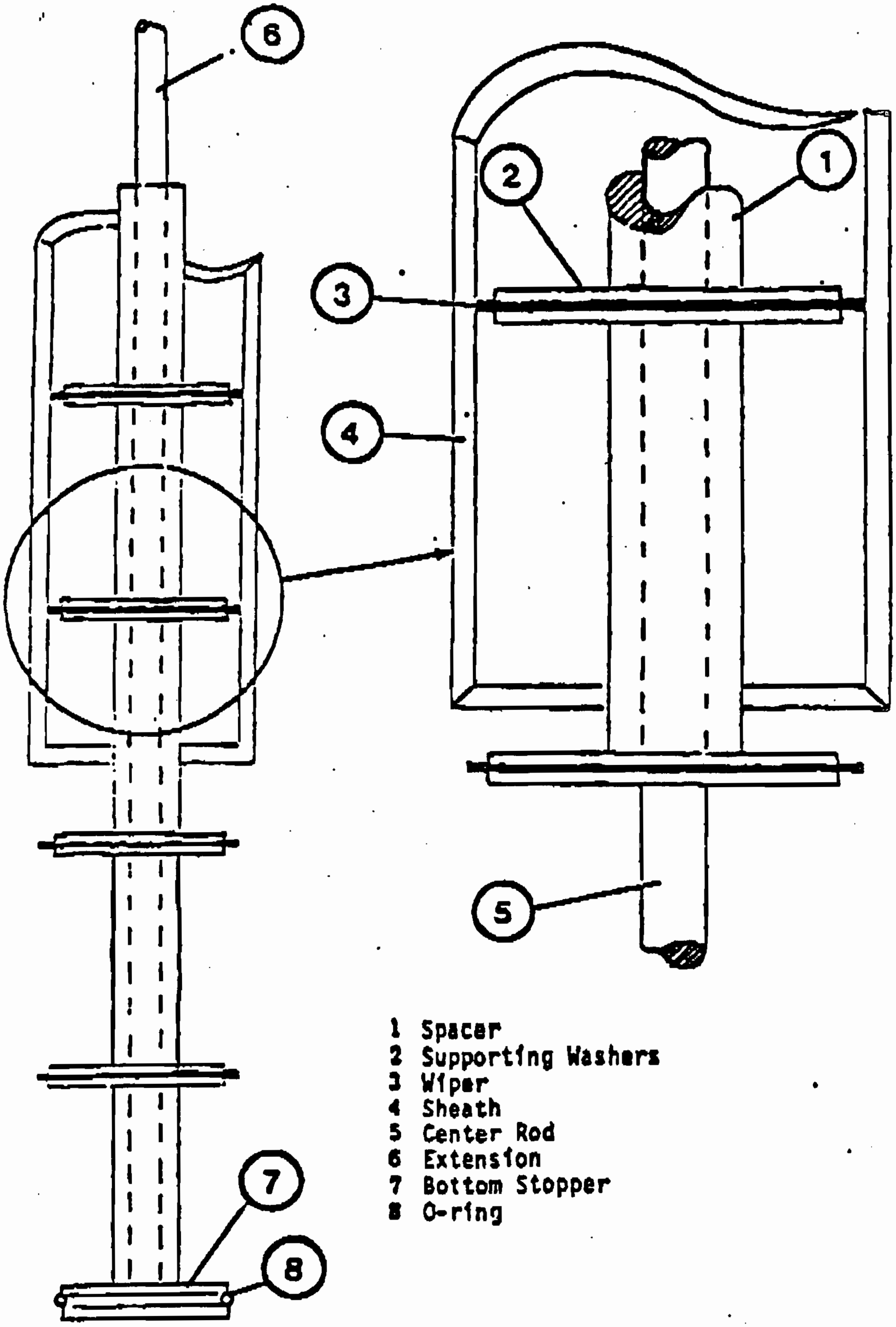


← C. The outer sheath is slid down the center section, trapping the liquid.

D. The entire sampler is withdrawn from the drum with a representative sample enclosed. →

[illegible]

STRATIFIED SAMPLE THIEF COMPONENTS



1 Spacer
2 Supporting Washers
3 Wiper
4 Sheath
5 Center Rod
6 Extension
7 Bottom Stopper
8 O-ring

COMPOSITE LIQUID WASTE SAMPLER (COLIWASA):

The Coliwasa is used to sample free flowing liquids and slurries contained in drums, shallow tanks, pits, and other similar containers. It is useful for sampling multi-phase wastes and can accommodate a wide range of viscosities, volatilities, and solids contents. The Coliwasa consists of a glass, plastic, or metal tube equipped with an end closure which can be opened and closed while the tube is submerged. A plastic Coliwasa should not be used to sample organic wastes unless it is constructed of fluorocarbon materials (Teflon). A glass Coliwasa should not be used to sample liquids containing hydrofluoric acid or high alkali concentrations.

Procedure for Use:

1. Select the tubing material compatible with the waste to be sampled and assemble the Coliwasa as shown in Figure 3-1.

2. Ensure that the Coliwasa is clean.

3. Adjust the locking mechanism, if necessary, to ensure that the neoprene stopper provides secure closure.

4. Wear necessary protective gear and observe required precautions.

5. Move the sampling mechanism to the open position by placing the stopper rod handle in the T position, and pushing the rod down until the T-handle sits against the sampler's locking block.

6. Slowly lower the sampler into the waste at a rate which permits the levels inside and outside the tube to be nearly equal. If the rate is too fast, a representative sample will not be obtained.

7. When the stopper hits the bottom of the waste container, push the tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests securely on the locking block.

8. Slowly withdraw the Coliwasa from the waste container with one hand, while wiping the tube with a disposable cloth with the other hand.

9. Carefully discharge the waste sample into a suitable container by slowly pulling the lower end of the T-handle away from the locking block.

10. Cap the sample container, attach label and seal, record in log book, and complete appropriate documentation.

11. Unscrew the T-handle of the sampler and disengage the locking block. Clean the sampler on site or store contaminated parts in a plastic tube for subsequent cleaning. Store used rags in plastic bags for subsequent disposal.

12. Deliver the sample to the laboratory for analysis.

If a significant amount of solids is present in the container bottom forming a separate layer, then a representative sample of the bottom layer of waste must be obtained along with the top layer. A Stratified Sample Thief is used and is described on page WAP-13g.1.

WEIGHTED BOTTLE:

The weighted bottle sampler is used to sample liquids and slurries in storage tanks, wells, sumps, or other containers which cannot be adequately sampled with a Coliwasa. The sampler consists of a glass or plastic bottle, a weight sinker, a bottle stopper, and a line that is used to open the bottle and lower and raise the sampler. ASTM D 270 and E 300 describe the equipment in further detail. The weighted bottle cannot be used to sample wastes which are incompatible with the weight sinker and line. A plastic bottle should not be used to sample organic wastes unless it is constructed of fluorocarbon materials (Teflon). A glass bottle should not be used to sample liquids containing hydrofluoric acid or high alkali concentrations.

Procedure for Use:

1. Select the bottle material compatible with the waste to be sampled and assemble the weighted bottle as shown in Figure 3-1.

2. Ensure that the weighted bottle is clean.

3. Wear necessary protective gear and observe required precautions.

4. Lower the sampler to the appropriate depth, and pull out the stopper with a sharp jerk of the sampler line.

5. Allow the bottle to fill completely. This is demonstrated by the cessation of air bubbles.

6. Withdraw the sampler from the waste and cap the bottle. Wipe the outside of the bottle with a disposable cloth. The bottle can serve as the sample container.

7. Attach label and seal, record in log book, and complete appropriate documentation.

8. Store used rags in plastic bags for subsequent disposal.

9. If a composite sample is desired, repeat sampling at appropriate points in accordance with Table 3-2 in Section 3.1.1.2.

10. Deliver the sample to the laboratory and specify whether analysis is to be performed on a composite of individual bottle samples.

DIPPER:

A dipper is used to sample free flowing liquids and slurries, and solids from pipes and conveyer belts. A dipper consists of a glass or plastic beaker clamped to the end of a telescoping aluminum or fiberglass pole. Dippers are not commercially available and must be fabricated. A plastic beaker should not be used to sample organic wastes unless it is constructed of fluorocarbon materials (Teflon). A glass beaker should not be used to sample liquids containing hydrofluoric acid or high alkali concentrations. An aluminum pole must be painted with a two part epoxy or other chemically-resistant paint when sampling alkaline or acidic wastes. When sampling process discharges, the beaker size should increase with increasing stream flow rate.

Procedure for Use:

1. Select the beaker material and size which is compatible with the waste to be sampled, and assemble the dipper as shown in Figure 3-1.

2. Ensure that the dipper is clean.

3. Wear necessary protective gear and observe required precautions.

4. Place the dipper into the waste and fill the beaker with the sample.

5. Slowly withdraw the beaker and wipe with a disposable cloth.

6. Carefully discharge the waste sample into a suitable container. If a composite sample is desired, repeat sampling at appropriate points in accordance with Table 3-2 in Section 3.1.1.2 and discharge into the same container.

7. Cap the sample container, attach label and seal, record in log book, and complete appropriate documentation.

8. Clean the sampler on site or store in plastic bag for subsequent cleaning. Store used rags in plastic bags for subsequent disposal.

9. Deliver the sample to the laboratory for analysis.

TRIER:

A trier is used to sample sludges, and moist or sticky solids with a particle diameter less than one-half the diameter of the trier. It can also be used to obtain soft or loosened soil samples to a depth of 61 cm. A trier consists of a tube cut in half lengthwise with a sharpened tip allowing it to cut into sticky solids and loosen soil. Triers are usually made of stainless steel with wooden handles. Triers 61 to 100 cm long and 1.27 to 2.54 cm in diameter are available commercially while larger ones can be fabricated.

<u>Procedure for Use</u>:

1. Assemble the trier as shown in Figure 3-1.

2. Ensure that the trier is clean.

3. Wear necessary protective gear and observe required precautions.

4. Insert the trier into the waste at a 0 - 45° angle from horizontal. This orientation minimizes spills. Rotate the trier once or twice to cut a core of material.

5. Slowly withdraw from the waste with the slot facing up and wipe with a disposable cloth.

6. Carefully discharge the sample into a suitable container with the aid of a spatula or brush. If a composite sample is desired, repeat sampling at appropriate points in accordance with Table 3-2 in Section 3.1.1.2 and discharge into the same container.

7. Cap the sample container, attach label and seal, record in log book, and complete appropriate documentation.

8. Clean the sampler on site or store in plastic bag for subsequent cleaning. Store used rags in plastic bags for subsequent disposal.

9. Deliver the sample to the laboratory for analysis.

SCOOP AND SHOVEL:

Scoops and shovels are used to sample granular or powdered material in bins, shallow containers, and conveyer belts. They can also be used to collect top surface soil samples. A laboratory scoop is similar to a garden trowel except the blade is more curved and it has a closed upper end for containment. Laboratory scoops are made of stainless steel or polypropylene.

Procedure for Use:

1. Select a sampler that is large enough to obtain a full cross section of waste.

2. Ensure that the sampler is clean.

3. Wear necessary protective gear and observe required precautions.

4. Insert the sampler into the waste and obtain a full cross section in one cross sweep.

5. Withdraw from the waste and wipe with a disposable cloth.

6. Carefully discharge the sample into a suitable container with the aid of a spatula or brush. If a composite sample is desired, repeat sampling at appropriate points in accordance with Table 3-2 in Section 3.1.1.2 and discharge into the same container.

7. Cap the sample container, attach label and seal, record in log book, and complete appropriate documentation.

8. Clean the sampler on site or store in plastic bag for subsequent cleaning. Store used rags in plastic bags for subsequent disposal.

9. Deliver the sample to the laboratory for analysis.

THIEF:

A thief is used to sample dry granules or powdered wastes with a particle diameter less than one third the width of its slots. A thief consists of two slotted concentric tubes constructed of stainless steel or brass. The outer tube has a conical pointed tip that permits the sampler to penetrate the material being sampled. The inner tube rotates to open and close the thief.

Procedure for Use:

1. Assemble the thief as shown in Figure 3-1.

2. Ensure that the thief is clean.

3. Wear necessary protective gear and observe required precautions.

4. Insert the thief into the waste and rotate the inner tube to the open position. Wiggle the sampler to encourage material flow into the tube.

5. Rotate the inner tube to the closed position and withdraw from the waste. Wipe with a disposable cloth.

6. Place the thief in a horizontal position with the slots facing up. Remove the inner tube and carefully discharge the sample into a suitable container. If a composite sample is desired, repeat sampling at appropriate points in accordance with Table 3-2 in Section 3.1.1.2 and discharge into the same container.

7. Cap the sample container, attach label and seal, record in log book, and complete appropriate documentation.

8. Clean the sampler on site or store in plastic bag for subsequent cleaning. Store used rags in plastic bags for subsequent disposal.

9. Deliver the sample to the laboratory for analysis.

STRATIFIED SAMPLE THIEF

The stratified sample thief consists of an inner rod holding variably spaced discs and surrounded by an outer sheath. The outer sheath forms a seal around the discs trapping the separate waste phases between the discs as illustrated on pages 12f and 12g. Stratified sample thiefs can be plastic or glass. A plastic thief should not be used to sample wastes containing ketones, nitrobenzene, dimethylforamide, mesityl oxide, and tetrahydrofuran.

Procedures of Use:

1. Select the material compatible with the waste to be sampled and assemble the stratified sampler.
2. Ensure that the thief is clean.
3. Wear necessary protective gear and observe required precautions.
4. Lower the sampler to the appropriate depth with the outer sheath raised to the open position.
5. When the desired depth is reached, slide the outer sheath over the discs and center section.
6. Withdraw the sampler and wipe the outside surface with a disposable cloth. Transfer each discrete sample into a separate container.
7. Attach label, seal, record in log book and complete appropriate documentation.
8. Store used rags in plastic bags for subsequent disposal.
9. Deliver the sample to the laboratory for analysis.

If the bottom phase is a tough or hardened solid which cannot be collected with the stratified sample thief, the upper phases in the container must be sampled first and than decanted. The lower phase can then be sampled using an auger as described in Section 3.1.1.1.

AUGER:

An auger is used to sample hard or packed solid wastes or soil. It consists of sharpened spiral blades attached to a hard metal central shaft. When the auger is rotated, it cuts through the waste material as it moves forward and discharges the loosened material to the surface.

<u>Procedure for Use</u>:

1. Ensure that the auger is clean.

2. Wear necessary protective gear and observe required precautions.

3. Insert the wooden T-handle into the socket.

4. Bore a hole through the middle of an aluminum pie pan large enough to allow the blades of the auger to pass through. The pan is used to catch the material brought to the surface.

5. Place the pan against the selected sampling point and begin augering through the hole until the desired depth is reached.

6. Back off the auger and transfer the material from the catch pan to a suitable container. Include material adhering to the auger. Spoon out the rest of the loosened material with a trier. If a composite sample is desired, repeat sampling at appropriate points in accordance with Table 3-2 in Section 3.1.1.2 and discharge into the same container.

7. Cap the sample container, attach label and seal, record in log book, and complete appropriate documentation.

8. Clean the sampler on site or store in plastic bag for subsequent cleaning.

9. Deliver the sample to the laboratory for analysis.

3.1.1.2 Sample Numbers, Locations, and Volumes

Table 3-2 summarizes required sample numbers and locations for liquid wastes, sludges and solid wastes in various containers. These requirements are based on characterizing the waste's variability in the vertical dimension. In many instances, appropriate sample numbers and locations vary with size and number of containers and, therefore, cannot be uniquely specified (Ref. h). When stratification or phase separation of container contents occurs, samples are composited throughout the entire depth of the container to ensure all phases are sampled. A Coliwasa is used when sampling all phases of multi-phased wastes (See Section 3.1.1.1). If depth compositing is not possible due to access limitations, this is noted and considered in interpreting analytical results (Ref. i). Sufficient volumes of representative samples are collected to address analytical needs. In most cases, 1000 ml (1 quart) allows for complete analysis. When a Coliwasa is used, the volume collected in the Coliwasa usually determines the volume of the sample (Ref. j).

3.1.1.3 Sampling Procedures

Procedures used for collecting samples from drums, tank trucks, railroad tank cars, bulk solids containers, barrels, fiberdrums, cans, bags, sacks, and storage tanks are given below (Ref. k, l). In each case, personal protective equipment is carefully selected depending on individual circumstances.

TABLE 3-2

RECOMMENDED NUMBER AND LOCATION OF SAMPLES

WASTE TYPE	WASTE CONTAINER	INFORMATION DESIRED	NUMBER AND LOCATION OF SAMPLES
Liquids and Slurries	Drum, Tank Truck, RR Tank Car	Average Concentration	1 sample collected with a Coliwasa
		Concentration Range	3 - 10 separate samples each from a different depth
	Storage Tank	Average Concentration	1 composite sample of several samples collected at different depths
		Concentration Range	3 - 10 separate samples each from a different depth
Sludges	Drum, Tank Truck	Average Concentration	1 sample collected with a Coliwasa
		Concentration Range	3 - 10 separate samples each from a different depth
	Open and Closed Bed-Trucks	Average Concentration	1 composite sample of several samples each collected at different depths
		Concentration Range	3 - 5 separate samples each from different sampling points
Powdered and Granular Solids	Bag, Drum, Bin, Sack, Open and Closed Bed-Trucks	Average Concentration	1 composite sample of several samples collected at different sampling points
		Concentration Range	3 - 5 separate samples each from different sampling points

(Source: Ref. g)

SAMPLING A DRUM:

1. Position the drum such that the bung is facing up. Drums with bungs on the ends should be upright, and drums with bungs on the sides should be sideways.

2. Allow the drum contents to settle.

3. Slowly loosen the bung with a bung wrench relieving any internal pressure.

4. Remove the bung and collect samples through the bung opening with the equipment specified in Table 3-1. Select the number and location of samples in accordance with Table 3-2.

5. When sampling multiple drums, each drum should ideally be sampled. However, if this is not practical, segregate the drums according to waste type and select a representative number of drums from each type. This is accomplished by assigning a number to each drum consecutively and using a random number table to choose the sample. A random number table is given in Table 3-3.

Drums containing liquid wastes may be under pressure or vacuum. A bulging drum usually indicates that it is under high pressure and should not be sampled until the pressure is safely relieved. A heavily corroded drum should be sampled with extreme caution as it may rupture and spill its contents when disturbed. Opening the bung of a drum may produce a spark which may detonate an explosive gas within the drum. This situation is difficult to predict and the use of spark-proof tools must be considered every time a drum is opened.

TABLE 3-3

RANDOM SAMPLING

03	47	43	73	86	36	96	47	36	61	46	98	63	71	62
97	74	24	67	62	42	81	14	57	20	42	53	32	37	32
16	76	62	27	66	56	50	26	71	07	32	90	79	78	53
12	56	85	99	26	96	96	68	27	31	05	03	72	93	15
55	59	56	35	64	38	54	82	46	22	31	62	43	09	90
16	22	77	94	39	49	54	43	54	82	17	37	93	23	78
84	42	17	53	31	57	24	55	06	88	77	04	74	47	67
63	01	63	78	59	16	95	55	67	19	98	10	50	71	75
33	21	12	34	29	78	64	56	07	82	52	42	07	44	38
57	60	86	32	44	09	47	27	96	54	49	17	46	09	62
18	18	07	92	46	44	17	16	58	09	79	83	86	19	62
26	62	38	97	75	84	16	07	44	99	83	11	46	32	24
23	42	40	64	74	82	97	77	77	81	07	45	32	14	08
52	36	28	19	95	50	92	26	11	97	00	56	76	31	38
37	85	94	35	12	83	39	50	08	30	42	34	07	96	88
70	29	17	12	13	40	33	20	38	26	13	89	51	03	74
56	62	18	37	35	96	83	50	87	75	97	12	25	93	47
99	49	57	22	77	88	42	95	45	72	16	64	36	16	00
16	08	15	04	72	33	27	14	34	09	45	59	34	68	49
31	16	93	32	43	50	27	89	87	19	20	15	37	00	49

HOW TO USE THE TABLE OF RANDOM NUMBERS:

1. Based on available information, segregate the containers (i.e., drums, sacks, etc.) according to waste types.
2. Number the containers containing the same waste types consecutively, starting from 01.
3. Multipy the number of containers for each waste type by 10 percent. This will be the number of samples to be taken. Make sure that at least 10 percent of each waste type is sampled - always round upwards. As an example, if there are 40 containers with the same waste type then at least 4 containers have to be sampled. (Note: if there were 41-50 containers, 5 containers must be sampled.)
4. Using the set of random numbers above, choose any number as a starting point.
5. From this number, go down the column, then to the next column to the right, or go in any predetermined direction until you have selected four numbers between 01 and 40, with no repetitions. Larger number are ineligible.

   Example: If you were to choose 46 as the starting point on column five, the next eligible numbers as you go down this column are 12,13 and 35. So far you have chosen <u>only</u> three eligible numbers. Proceed to the next column to the right. Going down and starting from the top of this column, the next eligible number would be 36. Your four random numbers, therefore, are 12, 13, 35 and 36. Thus the drums with corresponding numbers have to be sampled.

SAMPLING A TANK TRUCK/RAILROAD TANK CAR:

1. Allow the truck driver to open the hatch.

2. Assume a stable stance on the tank catwalk or access rung to the hatch.

3. Collect samples through each hatch opening with the equipment specified in Table 3-1. Select the number and location of samples in accordance with Table 3-2.

4. If necessary, take sediment samples from the tank through the drain spigot.

Sampling a tank truck or railroad tank car requires that the person collecting the samples either climb onto the tank and walk along a narrow catwalk, or climb access rungs to the tank hatch. This is often difficult when wearing protective gear. A second person must be available to hand the sampling device to the sampler and carry containers. The sample collector should position himself after the truck driver has opened the hatch. The tank is usually under pressure or vacuum and the hatch must be opened slowly.

SAMPLING A BARREL, FIBERDRUM, CAN, BAG, OR SACK CONTAINING POWDER OR GRANULAR WASTE:

1. Position barrels, fiberdrums, and cans upright. Leave bags and sacks in the positions they are found as disturbing them may cause a rupture or leak.

2. Collect samples through the tops of barrels, fiberdrums, buckets, and cans, and through fill openings in bags and sacks using the equipment specified in Table 3-1. Collect samples through the center of the containers and to different points diagonally opposite the point of entry, or as specified in Table 3-2.

3. When sampling multiple containers, each container should ideally be sampled. However, if this is not practical, segregate the containers according to waste type and select a representative number of containers from each type. This is accomplished by assigning a number to each container consecutively and using a random number table to choose the sample. A random number table is given in Table 3-3.

SAMPLING A STORAGE TANK:

1. Climb to the top of the tank and open the sampling hole.

2. Collect samples from the sampling hole using the sampling equipment specified in Table 3-1. Collect one sample each from the upper, middle, and lower sections of the tank and combine in one container, or as specified in Table 3-2.

Sampling a storage tank requires climbing a narrow vertical or spiral stairway while wearing protective gear and carrying sampling equipment. A second person must be on hand, usually at the head of the stairway, to observe and be ready to assist or call for help.

SAMPLING A BULK SOLIDS CONTAINER

1. On a diagram divide the container into four equal quadrants.

2. Collect one composite sample from each quadrant using a hollow-stemmed auger combined with a split spoon sampler or trier. A scoop, shovel or thief may also be used.

3. Each composite sample must be obtained by collecting and mixing a sufficient number of core samples to represent the entire depth of the container.

Sampling bulk solids containers require climbing a ladder and assuming a stable position above each sampling point while wearing protective gear and carrying sampling equipment. A second person must be on hand, usually at the head of the ladder, to observe and be ready to assist or call for help.

3.1.2 <u>Sampling for Process/Residual Line Analysis</u>

Representative samples from process/residual line discharges are obtained through time composite sampling. Applicable streams include waste feeds, auxiliary fuel, scrubbing liquid (inlet and outlet), and ash. Time composite sampling involves collecting a number of grab samples of equal volume at regular time intervals to adequately characterize variations in process flow over time. The individual grab samples are then combined into a series of composite samples. Variables such as the frequency of collection, points of collection, and number of samples taken are process-dependent and are selected based on the expected variability of the waste composition. The volume of waste collected is sufficient to address analytical needs. The sampler varies in size in accordance with the flow rate of the process stream. Sampling from process/residual lines varies somewhat with the physical state of the waste as discussed below (Ref. m).

3.1.2.1 Liquids and Slurries

Liquids and slurries are sampled from pipes and valves using a dipper as discussed in Section 3.1.1.1. The dipper is passed through the discharge stream such that the beaker or bucket is filled in one sweeping motion. If the cross sectional area of the stream is large in comparison to the dipper size, more than one pass is necessary to account for spatial variability. Samples from multiple sweeps are emptied into the same container and mixed (Ref. n).

3.1.2.2 Solid and Semi-solid Process Discharges

Solids and semi-solids are often sampled from conveyer belts or filter presses. Solids on conveyer belts are sampled with a scoop or shovel as discussed in Section 3.1.1.1. The grab samples are taken from any convenient point along the belt as long as the entire width of the belt is sampled to account for spatial variability. Any fines or liquids present at the sampling point are included in the grab samples.

Filter cake collected in a hopper or storage area is sampled after it has accumulated over a period of time. Sampling is performed with a thief or trier as discussed in Section 3.1.1.1. If phase separation occurs in the hopper, the waste is thoroughly mixed before samples are collected. Grab samples are collected from various locations and combined into a composite sample. The number and location of grab samples is dependent on the size of the container. Filter cake samples may also be collected as the material is produced. In this case, a shovel or scoop is used to collect individual samples from various locations representing the entire waste stream. A composite sample is obtained by combining and mixing the individual samples in one container (Ref. n).

3.2 SAMPLE HANDLING

3.2.1 Containers

Immediately after collection, representative samples are transferred from the samplers to wide mouth containers as discussed in Section 3.1.1.1. Sample containers are selected based on compatibility, resistance to breakage, volume, and cost. Containers are made of high density or linear polyethylene, conventional polyethylene, polypropylene, polycarbonate, Teflon FEP, polyvinylchloride, polymethylpentene, and glass. Air tight containers are used for samples requiring analysis for volatile compounds. Tight, screw-type closures are provided with all containers (Ref. o, p).

3.2.2 Preservation and Storage

Immediately after the samples are transferred into containers, the containers are tightly capped to prevent loss of volatile compounds and possible oxidation. The samples are stored at 4 to 6 ^{o}F and, if only one or two components are to be analyzed, treated with a preservative. Samples are stored in the laboratory and analyzed as quickly as possible after collection (Ref. q). Preservation times will not exceed those described in EPA's Test Methods for Evaluating Solid Waste, Volume I, Laboratory Manual, Physical/Chemical Methods (SW-846), 3rd Edition.

3.2.3 Labeling

The samples are labeled with the generator name, waste type, date and time of collection, purchase order number, and initialed by the sampling personnel. They will also identify whether the sample is a grab or composite sample and will have an inventory number which will correlate with the work order in the laboratory describing the type of analysis to be run. The inventory number will also track to the Waste Container Inventory Log (D-25) or the Tank Inventory Log (D-48), as appropriate. The label information on each sample ensures that the samples are properly tracked and easily identified or retrieved. For samples received from the generator for pre-acceptance analysis, the sample label is part of the generator's Pre-Acceptance Waste Characterization Sheet. The register number on the label matches the number on the Pre-Acceptance Waste Characterization Sheet. The generator completes the sheet and label, and attaches the label to the representative sample. Upon receipt, the laboratory checks the sample label against the characterization sheet to verify the sample identity.

3.2.4 Sample Tracking

A record of all samples received by the laboratory is kept in a laboratory log. Upon completion of the laboratory analysis, the Laboratory Manager or Chemist dates and initials the log entry. In this way, all samples can be tracked through the laboratory and the current status of all samples can be determined. All waste samples are retained for a minimum of three months after the analysis is completed or six weeks post-treatment, whichever is longer, and report filed.

3.2.5 Sample Disposal

The sample liquid is collected and processed as hazardous waste while at the facility. Sample disposal is performed in accordance with Federal, state, and local regulations. Each container is drained of all free liquid, crushed, and sealed in drums for transport to approved treatment, storage, and disposal facilities.

A flow diagram for the complete sampling scheme is given in Figure 3-2.

FIGURE 3-2

SAMPLING AND SAMPLE HANDLING PROCEDURE FLOW CHART

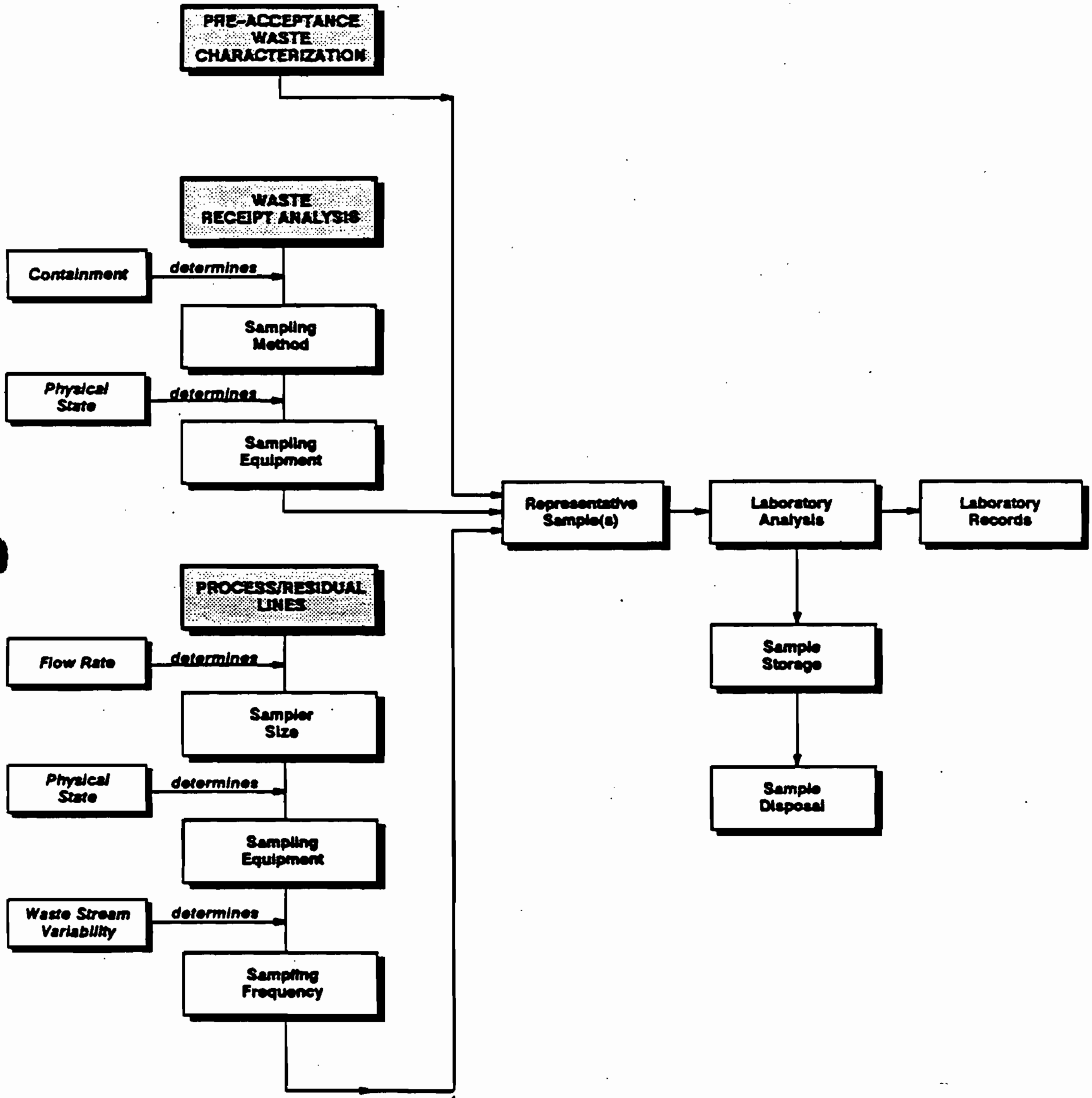


TABLE 3-4

REFERENCES FOR SECTION 3.0

Ref. a	U.S. Environmental Protection Agency, Samplers and Sampling Procedures for Hazardous Waste Streams, EPA-600/2-80-018, Municipal Environmental Research Laboratory, Cincinnati, OH, January, 1980, pps. 5-9, 11-15, 22-23.
Ref. b	U.S. Environmental Protection Agency, Test Methods for Evaluating Solid Waste, Volume II; Field Manual, Physical/Chemical Methods, SW-846, Office of Solid Waste and Emergency Response, Washington, D.C., Third Edition, November 1986, pps. NINE/49-55.
Ref. c	American Society for Testing and Materials, 1988 Annual Book of ASTM Standards, Philadelphia, PA, ASTM D 270, ASTM E 300.
Ref. d	Ref. a, p. 29.
Ref. e	Ref. b, p. NINE/48.
Ref. f	U.S. Environmental Protection Agency, Petitions to Delist Hazardous Wastes, A Guidance Manual, EPA/530-SW-85-003, Office of Solid Waste, April, 1985, p. 40.
Ref. g	Ref. a, p. 34.
Ref. h	Ref. f, pps. 30-31.
Ref. i	U.S. Environmental Protection Agency, Region IV, Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual, Environmental Services Division, Athens, GA, April, 1986, section 4.11, p. 4 of 7.
Ref. j	Ref. a, p. 33.
Ref. k	Ref. a, pps. 32, 36-39.
Ref. l	Ref. d, p. 40.
Ref. m	Ref. d, p. 30.
Ref. n	Ref. d, p. 38-39.
Ref. o	Ref. a, pps. 27-28, 30.
Ref. p	Ref. b, pps. 47, 49.
Ref. q	Ref. a, pps. 39, 48-49.

4.0 ANALYTICAL PARAMETERS, RATIONALE, AND TEST METHODS

Various parameters of wastes are used to initially characterize the wastes before receipt and to confirm upon receipt that the wastes match the manifests, shipping papers, pre-acceptance waste characterization, previous shipments, or any combination of these identifying data. Laboratory analyses are to be conducted on-site. All laboratory logs and results of the waste analyses described in this section will be kept in the operating record of the facility.

4.1 PRE-ACCEPTANCE ANALYSIS

For pre-acceptance waste characterization, the data provided by the generator are supplemented with analysis of the submitted representative samples. The steps taken to characterize the representative samples are shown graphically on Figure 4-1.

The sample is first assessed for phase description. Each phase of multi-phase wastes is ~~sampled and~~ analyzed. The basic fingerprint parameters listed in Table 4-1 are analyzed for all wastes using the relevant test methods noted in parentheses to provide proper identification traits of the waste to be used at the time of receipt. The parameters, rationale, and test methods are given in Table 4-1 in accordance with 40 CFR 264.13(b). Some of this fingerprinting information obtained from the basic analytical methods is used to conduct further testing to determine the optional parameters for further characterizing the waste with regard to its compatibility qualities and its amenability to either inorganic treatment or incineration. Special testing may be conducted if more information is necessary to safely and appropriately process the waste.

If the generator identifies on the Pre-Acceptance Waste Characterization Sheet that the waste contains one or more of the listed 21 toxic constituents (see Figure 2-1), then further analysis will be performed to determine if the waste contains significant amounts of the noted toxic constituent(s). If the concentration of the toxic constituent(s) is close to the RCRA corrective action level for that constituent such that permit or operating constraints on the feed rate may be exceeded, then the waste will be further analyzed for treatability as described in Section 4.3.

TABLE 4-1
(Continued)

PARAMETERS AND RATIONALE

TREATABILITY/PROCESSING ANALYSES

1. Heavy Metals Content (e.g., As, Ba, Cd, Cr, Hexavalent Cr, Pb, Hg, Ni, Se, Ag) quantifies heavy metal concentration to determine process operating parameters. (SW-846 Methods 7060, 7080, 7090, 7190, 7195, 7420, 7470, 7520, 7740, 7760, respectively, or equivalent approved methods)

2. Organic Content is used to decide whether there is too much organics for processing in the inorganic treatment units and whether the wastes are better processed through the incinerator. Any waste that is determined to contain more than 10% total organics or 1% volatile organics will not be inorganically treated, but will be incinerated. (SW-846 Methods 8010, 8015, 8020, 8240, 8250, etc.; i.e., Gas Chromatographic/Mass Spectroscopy Methods)

3. Heat Value (Btu) is used to establish the proper blend characteristics and evaluate its suitability for incineration. There are no acceptance limits for incoming waste loads based on heat value. Heat value of a particular blend is controlled by the incinerator feed blend. (ASTM D240-85)

4. Chlorine Content is used to establish the proper blend characteristics, and/or evaluate potential impacts on the incinerator and/or pollution control equipment. There are no acceptance limits for halogen content in incoming waste loads. Chlorine content is controlled by the incinerator feed blend. (ASTM D808-81)

SPECIAL ANALYSES

1. Viscosity is determined to ensure that the waste remains a pumpable and burnable liquid. (ASTM D445)

2. Priority Pollutant Content (volatile organics, acid-base clean-up extracts) is used to check for significant concentrations of hazardous components. (SW-846 Methods 8240 and 3530)

3. Ash Content is used to aid in conforming to permit levels and to predict other operational impacts on the incinerator and air pollution control equipment (e.g., particulate generation, inorganic solid residue formation). There are no acceptance limits for ash content in incoming waste loads. Ash content is controlled by the incinerator feed blend. (ASTM D482-80)

4. Water Content is determined to ensure that solid wastes do not contain any free liquids. (SW-846 Method 9095, i.e., Paint Filter Test)

All receipt analysis is recorded on standard FFP-LP forms. Figure 4-2 shows an example of a Waste Receipt Laboratory Analysis Worksheet. Forms may be modified for a particular situation, or to improve their usefulness or data accessibility.

4.3 TREATABILITY/PROCESSING ANALYSIS

Treatability analysis may be conducted if there is a need for greater knowledge of the amenability of the wastes to treatment alternatives at the facility, and if it is necessary to anticipate the characteristics of the process residuals such as incinerator ash and filter cake to facilitate proper handling, re-use or disposal. The worksheet used is shown on Figure 4-3.

The test parameters which help determine the suitability of wastes for incineration are, for example, heat value (BTU), chlorine content, and metal content. Knowledge of these parameters enables facility operators to adequately and appropriately blend the wastes to meet waste feed specifications, and set the optimum feed rate. A composite sample of blended containerized or bulk wastes may be analyzed before feeding into the incinerator, particularly if the blended wastes contain one or more of the listed 21 toxic constituents as identified on the Pre-Acceptance Waste Characterization Sheet. U.S. EPA Methods prescribed in SW-846, e.g., Gas Chromatographic/Mass Spectroscopy Methods, will be used to analyze for these constituents. In heat and mass balance calculations used to set the feed rate, the two variables that can be offset against each other are heat content and chlorine loading. If the thermal loading of the waste feed approaches the upper limit, the feed rate is to be reduced to cut down on the heat content or chlorine loading of the feed.

Other optional tests are conducted to analyze treatability parameters for more information on the amenability of wastes to inorganic treatment at the facility. The parameters and the tests are described in Table 4-1. For example, the test using SW-846 Method 7195 may be conducted to determine the hexavalent chromium content in the waste in order to set an appropriate feed rate for the metal reduction process. Tests for metals are dispensed with if the waste is clearly identified from knowledge of the generating process or prior analyses. Tests for the oxidation of cyanides and sulfides may be conducted, if necessary.

Post-incineration or inorganic treatment analyses are conducted to prepare for the next stage of re-use, storage, treatment, or disposal alternatives. Incinerator ash and fabric filter solids are tested to ensure that the treatment residue has acceptable characteristics such as low levels of reactive or leachable cyanide and organic toxicants, in order that the residue may be effectively managed, e.g. by stabilization using cement and fly ash. Effluent from the inorganic treatment units, after being processed at an on-site wastewater treatment plant, is analyzed and characterized in order to ensure its suitability for use as cooling water or spray dry water in the incineration unit.

4.4 FREQUENCY OF ANALYSIS

All waste shipments will be analyzed at least for fingerprint parameters, as outlined in Section 4-1 and listed in Table 4-1 to verify the accuracy of the pre-shipment characterization. Additionally, all wastes received for the first time will go through treatability analysis as described in Section 4.3. However, a detailed waste analysis will be conducted once a year, to verify the consistency of waste or residue streams shipped to FFP-LP on a continual basis. This detailed analysis will consist of those parameters included in the generator's pre-acceptance waste characterization sheet. In addition, if production/process changes or upsets occur which could alter the characteristics of the waste or residue stream, or if there are manifest discrepancies, the waste analyses will also be repeated, in accordance with 40 CFR 264.13(b)(4).

5.0 PROCESS OPERATIONS

When a bulk waste shipment is accepted, it is assigned to a storage tank after a representative sample is collected in accordance with procedures specified in Section 3.1.1. For pumpable containerized waste shipments, the contents are transferred to storage tanks after 10% sampling and lab analysis. Prior to transferring the waste, the storage tank is checked for compatibility with the waste by reviewing analytical descriptions of the waste against standard compatibility tables as shown in Section D (Process Information) of this permit application. The facility maintains records of each off-loaded shipment and the contents of each storage tank so as to ensure the compatibility of the waste load with the current contents of the designated storage tank.

5.1 CONTAINER PROCESSING

Ten percent of the containers in any movement of hazardous wastes received at the facility are sampled and analyzed to determine the accuracy of the manifest identification (See Section 2.2). Parameters determined from the analysis of the wastes and compatibility tests similar to those described in Section 5.2 enable the proper handling of these containerized shipments according to their waste type and compatibility traits.

Low viscosity organic wastes are pumped into storage tanks or directly fed into the incinerator. Non-pumpable high viscosity organic wastes in fiber and plastic drums are fed directly into the incinerator through the kiln feed chute. Steel drums which contain free liquid are processed to transfer their contents to a waste receiving tank which feeds wastes into the incinerator. The containers are then shredded and fed into the incinerator. If the waste sampling and analyses confirm that the wastes received are more amenable to inorganic treatment, the container processing system feeds the wastes either into the appropriate inorganic waste storage tanks or directly into the inorganic waste treatment reactors.

5.2 TANK STORAGE

When the compatibility characteristics of a waste are uncertain, a compatibility test will be performed to check whether it is appropriate to place the incoming waste load into designated storage tanks. A representative sample from the incoming waste shipment is mixed with a representative sample from the targeted receiving tanks to evaluate compatibility characteristics. The sample from the incoming shipment is collected in accordance with procedures specified in Section 3.1.1 for the particular waste type and container. The sample from the receiving tank is collected in accordance with the procedure specified in Section 3.1.1.3 for sampling a storage tank. The samples are mixed in their expected proportions in the targeted tank in a vial or other appropriate laboratory equipment. Mixing is performed under a ventilated hood. Upon mixing, the following reactions are noted:

- The generation of heat and/or gas;
- Any increase in stratification or viscosity; and
- Any bubbling, spattering, fuming, precipitation, gelling, and/or solidification.

If the test mixture exhibits any of the above characteristics, the wastes are identified as incompatible. The test is repeated until a suitable tank is found.

The wastes are stored in tanks temporarily prior to incineration and are sometimes blended to meet the incinerator waste feed specifications. Once an adequate amount is accumulated and the blend meets specifications, the waste is transferred to the incinerator.

5.3 INORGANIC TREATMENT

Wastes determined from receipt analysis and/or pre-acceptance waste characterization to be inorganic are processed through the inorganic treatment system. Wastes that can be pumped as determined by analytical parameters such as physical description or viscosity are stored in inorganic waste storage tanks and then transferred to the treatment system. Non-pumpable waste are fed directly into the reactors at the inorganic waste treatment system.

The receipt procedures and analyses are also used to determine the approximate quantity of appropriate reagents to be used to treat each batch of waste in the cyanide reactor or the multipurpose reactor. The composition of the wastes in each batch is documented by means of a Waste Inventory System using inventory logs such as those provided in Section D of this application (Figures D-3-1 and D-4-1) and waste characterization data sheets such as those shown in Figures 2-1, 4-2, and 4-3 of this Plan. Based on the documented composition of each batch of waste, the volumes of wastes fed to the treatment reactors are monitored and regulated to ensure that safe operating and permit conditions are maintained.

The resulting filter cake from the treatment is generally sampled, in accordance with procedures specified in Section 3.1.2, analyzed, and weighed after each batch, as necessary, or at least according to the required frequency specified in Section 4.4 of this Plan, to ensure that proper waste identification and characterization is available to transmit to the off-site treatment, storage, and disposal facilities and to demonstrate and certify adherence to the applicable treatment standards required for the wastes in accordance with 40 CFR 268.7. Copies of waste receipt manifests, inventory logs, waste characterization sheets, and residue analysis records are attached to document the treatment of manifested waste. The resulting effluent liquids are continuously monitored prior to introduction into the incineration system via the filtrate buffer tank to ensure that the effluent is within the incinerator waste feed's physical and chemical composition limits as set in the operating permit. This is accomplished by sampling the effluent in a holding tank after it is discharged from the filter presses prior to being conveyed to the filtrate buffer tank. Sampling is performed in accordance with Section 3.1.1.3. The frequency of sampling the holding tank will depend on the solids/liquid composition of the sludge entering the filter presses.

5.4 INCINERATION

In this process, liquid, semi-solid, and solid wastes are destroyed by high-temperature thermal oxidation. The resulting streams include off-gases that are scrubbed and ash that can be stabilized and then stored or landfilled.

The analyses conducted in Section 4.0 categorize the feed wastes to ensure that the facility permit and operational constraints are met. All wastes are evaluated for compatibility with system design and operating parameters as well as permit limitations. This procedure screens waste that is not acceptable, and includes recordkeeping and/or testing of all blended waste in each burn campaign that is fed to the incinerator. The composition of the wastes fed to the incinerator during the burn campaign will be documented by means of a Waste Inventory System, using inventory logs such as those provided in Section D of this application (Figures D-3-1 and D-4-1) and waste characterization data sheets such as those shown in Figures 2-1, 4-2, and 4-3 of this Plan. Based on the documented composition of each waste type, the waste feed rates to the incinerator are continuously monitored and regulated via instrumentation such as flowmeters and container counters to ensure that safe operating and permit conditions are maintained.

The optional treatability analyses are applied, as necessary, to the blended waste feed. For instance, a range of acceptable heat values of the waste feed will be established from the results of the trial burn described in Appendix D-6. Low Btu/lb wastes are blended with other wastes to achieve the desired heat value. Any metals which might be at levels of concern in the waste feed (as revealed by the metals trial burn) are tested, as necessary. Once the appropriate levels and feed parameters of each batch are set, the feed is continuously monitored and regulated via instrumentation such as flowmeters or container counters to ensure that safe operating and permit conditions are met.

Post-treatment analyses are conducted to characterize the scrubber effluent and ash. All ash and dry scrubber solids generated are transferred to a secure hazardous waste disposal facility; these residuals may be stabilized before being transferred off-site. At this time, the stabilized waste residue will be handled as a hazardous waste. A delisting petition may be submitted at a later date if the characteristics of the stabilized waste residue are determined to meet the delisting criteria. Ash resulting from on-site treatment of land disposal restricted wastes is generally analyzed and evaluated, as needed, after each batch or at least according to the required frequency specified in Section 4.4 of this Plan, against ~~Extraction Procedure~~ Toxicity Characteristic Leaching Procedure (TCLP) values, or appropriate standards in accordance with 40 CFR 268.7. Copies of waste receipt manifests, inventory logs, waste characterization data sheets, and residue analysis records are attached to document the treatment of manifested waste. To confirm the absence of free liquids in the process residuals prior to off-site waste management, the paint filter test referenced in Table 4-1 may be conducted.

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Florida First Processing, Inc.

Volume I
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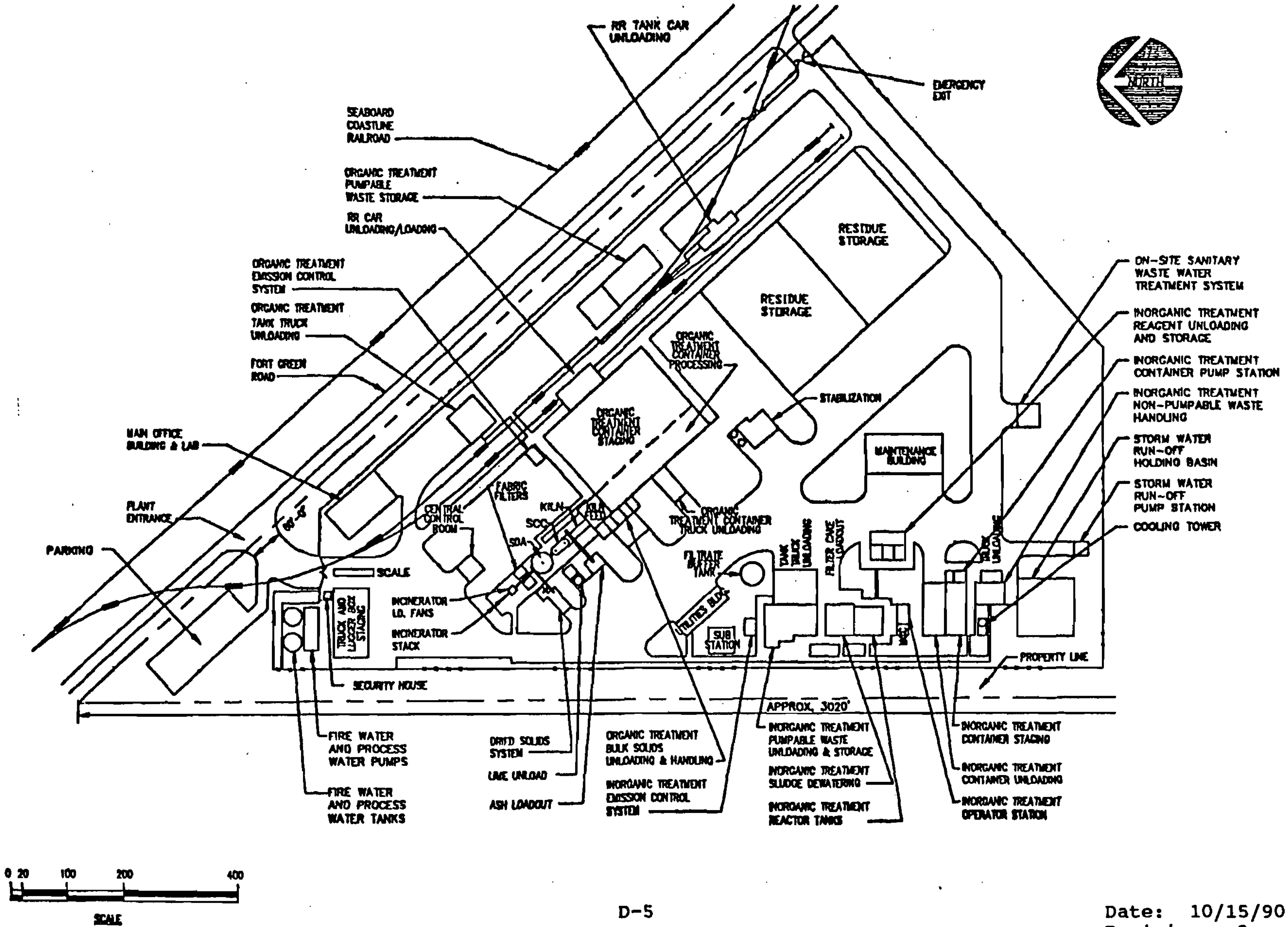
FIGURE D-1-1 [This figure has been revised]

SITE PLAN



D.1 CONTAINER AND BULK UNLOADING/LOADING AREAS

During the normal flow of operations at the FFP-LP facility, the first group of areas that wastes will be routed through are the Truck Unloading Areas and Railcar Unloading Areas. There will be different unloading/loading areas for containerized wastes and bulk solids ~~wastes~~. The unloading/loading areas will further be differentiated according to the types of waste handled and the treatment alternative they are assigned to. This determination of unloading/loading area assignments will be made according to pre-acceptance waste characterization data, manifest information, and waste receipt fingerprint analyses as described by the Waste Analysis Plan in Appendix C.

D.1.1 Organic Treatment Container Truck Unloading Area

Trucks carrying containerized wastes will enter the facility through the main gate, check in at the security house (where the presence of shipping papers is verified), and proceed south on the facility's asphalt roads to the appropriate Container Truck Unloading Area. Trucks carrying containerized wastes intended for incineration will be directed to the Organic Treatment Container Truck Unloading Area which will be located west of the Organic Treatment Pumpable Waste Storage Area (see Figure D-1-1). The design of and unloading procedures at the Truck Unloading Area are given below. The receipt analysis of the waste shipments will commence at the Truck Unloading Area, in accordance with the Waste Analysis Plan in Appendix C.

There will be two dock bays at the Organic Treatment Container Truck Unloading Area for unloading containers from trucks. The Truck Unloading Area is designed with a secondary containment system to adequately hold the volume of at least ten percent of the capacity of one truck load of containers (i.e., greater than 440 gallons). See Appendix D-2 for the supporting calculations of containment capacity. The secondary containment system will consist of a driver will move drums to the rear of the container truck (e.g. trailer or cargo van) in groups of one or two drums using a heavy-duty drum cart. FFP-LP personnel will then operate a forklift equipped with grappling tongs to securely grab these drums and remove them from the truck. All forklift operators will be FFP-LP personnel thoroughly trained in container handling and emergency response procedures to minimize the possibility of accidents.

In the unlikely event that a spill occurs, waste will be contained within the staging area or within the Truck Unloading Area's secondary containment system. The sump located at the low point of the unloading bay will collect any spills, should a container be punctured by the forklift or should discharge after a fall within the truck trailer or outside the truck into the truck bay. Any liquid collected in the sump will be promptly removed by a vacuum tank truck to an appropriate storage tank.

Using pre-acceptance data, manifest information, or fingerprint analyses, the containers will be separated into either an empty storage zone or a zone holding containers of compatible waste in the Container Staging Area. The compatibility chart and tests that will be utilized to assign staging zones are given in the Waste Analysis Plan (Appendix C). The inventory log shown in Figure D-3-1 in Section D.3.1.2 will be used to identify compatible containers. Instead of being stored in the Container Staging Area, the containers may be moved directly from the Truck Unloading Area to the Container Processing Area within the same building.

D.1.2 Inorganic Treatment Container Unloading Area

Wastes intended for inorganic treatment will be unloaded at the Inorganic Treatment Container Unloading Area toward the southwest of the facility (see Figure D-1-1). This Unloading Area will be located adjacent to the north

D.1.3 **Railroad Car Unloading Area**

The Railroad Car Unloading Area located west of the Organic Treatment Pumpable Waste Storage Area will be the designated unloading area for all containers arriving by rail (see Figure D-1-1). A secondary containment system is designed for the Unloading Area to adequately hold at least 10% of the container capacity of one railcar. The calculations demonstrating that this Unloading Area will have adequate secondary containment are provided on sheet 8 of 12 of Appendix D-2. The secondary containment system will consist of a curb on one end, raised entrance ramps at two ends, and the walls of the Organic Treatment Container Staging Area at one end. The base of the Unloading Area will slope towards a trench parallel to the railroad tracks. See Appendix D-5, Drawing 8813-00-M-025 for the engineering design of the containment system. Drawing 8813-00-S-016 shows the foundation support that will be provided at the Unloading Area. Additionally, the Unloading Area will be covered with a roof to keep out rain and hail. Inspections will be conducted to maintain the integrity of all features of this area.

The containers in the railroad cars will be transferred to the Container Staging Area according to the unloading and handling procedures provided in the truck unloading section (Section D.1.1). The procedure to manually unload un-palletized containers given in Section D.1.1 will be particularly applicable since most containers will arrive loaded that way in the railroad cars. An exception in this procedure is that plant personnel will unload drums from the railcars since railroad personnel will not perform that task. As with other container unloading areas, the wastes may either be transferred to an appropriate Staging Area or prepared for immediate processing through the treatment units.

Lugger boxes arriving by rail will be unloaded by a bridge crane. The bridge crane will be located in this unloading area and have containment as described above. The bridge crane will be specially equipped for handling lugger boxes and will be manually operated from ground level by means of a pendant. After manifest review and sampling according to the procedures provided in the truck unloading section (Section D.1.1), the lugger boxes will be lifted off the rail cars and loaded onto trucks. The trucks will either dump the contents of the boxes into the bulk solids receiving bins for processing, or temporarily stage the boxes in the lugger box staging area.

The bridge crane will also be used for loading lugger boxes containing residues onto rail cars for transport to a landfill. The boxes will be transferred from the residue storage area by trucks or heavy forklifts to the Railroad Car Unloading Area, where the bridge crane will lift the boxes onto the rail cars.

D.1.4 Organic Treatment Tank Truck Unloading Area

The Organic Treatment Tank Truck Unloading Area will be located at the north end of the facility (see Figure D-1-1). The bulk liquids storage tanks located in the Organic Treatment Pumpable Waste Storage Area and associated with the incineration system will be served by three unloading bays within this Truck Unloading Area. These unloading bays will be surrounded by a concrete curb on three sides and a gradual rise in the pavement just before the entrance to divert stormwater run-on away from this Unloading Area.

The inside of the Truck Unloading Area is designed with a trench intersecting the unloading bays at right angles to the direction of truck travel. The concrete base of the containment area will slope towards the trenches, which in turn slope toward a sump. These features are designed to provide secondary containment capacity for at least the entire contents of a 6,000-gallon tank truck. Tank Trucks containing more than 6,000 gallons will not be accepted at this facility. Any liquid collected in the sump will be promptly removed by a vacuum tank truck to an appropriate storage tank. See Appendix D-2 (sheet 4 of 11) for secondary containment calculations. A sloped roof will be built over the Truck Unloading Area to prevent rainfall accumulation in this area. See Appendix D-5, Drawing 8813-00-M-011, for design details of the secondary containment system and the building. See Appendix D-5, Drawing 8813-00-S-002 for the plan and section views of the foundation structure.

The Tank Truck Unloading Area will be able to accommodate several different types of waste shipments in its three bays, among them:

- High and Low-Btu Liquids ~~organic waste~~;
- Sludge; and
- ~~Direct-burn waste; and~~
- Waste from a vacuum tank truck.

The unloading pumps for transferring pumpable wastes to the Organic Treatment Pumpable Waste Storage Area will also be located within this covered and curbed Unloading Area. Dedicated piping and a pump for fuel oil unloading will also be installed in the Unloading Area. ~~In the bays designated for sludge and direct burn waste unloading,~~ Nitrogen will be provided in the bays for inerting flammable waste and for maintaining pumping pressure. Fugitive emissions from the tank trucks will be vented through a carbon adsorber during tank truck loading and unloading.

After the wastes are unloaded, the tank trucks are cleaned within the containment systems of these three bays before they leave the facility. The tanks are cleaned on the inside with hot soapy water. Any waste residues on the outside of the tank truck will be cleaned off with cold water. The water from these cleaning operations will flow into the sump in the containment area. This water will be removed by a vacuum tank truck and transferred to an appropriate storage tank.

D.1.5 Inorganic Treatment Pumpable Waste Unloading Area

The Inorganic Treatment Pumpable Waste Unloading Area will be located on the east side of the Inorganic Treatment Pumpable Waste Storage Area (see Figure D-1-1). The bulk liquids storage tanks associated with the inorganic treatment system will be served by four separate unloading bays. There will be four secondary containment areas within the station, each providing segregated containment for an unloading bay. Each of the containment areas will be surrounded by a concrete curb to provide containment capacity for at least the entire contents of a 6,000-gallon tank truck. The concrete curb will also prevent rainwater run-on. A gradual rise in the pavement just before the entrance to this Unloading Area will divert stormwater run-on away

D.1.6 Railroad Tank Car Unloading Area

FFP-LP will accept waste shipments by rail, in tank cars of up to 30,000 gallons. The Railroad Tank Car Unloading Area where these shipments will be pumped out will be located west of the Organic Treatment Pumpable Waste Storage Area (see Figure D-1-1). This Unloading Area is designed with a secondary containment system to handle the full load of a railroad tank car. There will be a containment pit that runs underneath the railroad tracks that slopes from a depth of five feet down to six feet into a trench intersecting the Unloading Area at right angles to the tracks. The trench will be one-foot deep at its shallowest point and slope into a sump two and a half feet deep. Secondary containment will be provided for 30,000 gallons within this pit and trench system as demonstrated in Appendix D-2 (sheet 7 of 11). Any liquids accumulated in the containment system will be removed by vacuum trucks or similar means in a timely manner. A roof over the Unloading Area will provide protection from the heavy Florida rain storms. Containment system design details are provided in Appendix D-5, Drawing 8813-00-M-013 and foundation details in Drawing 8813-00-S-012.

An unloading/transfer pump will be located in a curbed area beside the railroad tracks to facilitate the unloading of the railroad tank car. During the emptying, fugitive emissions from the railroad tank car will be vented to the atmosphere through a carbon adsorber bed. When the railroad tank car has been emptied, the inside of the tank may be cleaned with hot soapy water, while any spills on the outside of the railroad tank car may be washed off with cold water. The wash water will be removed from the containment area with a vacuum tank truck and placed in a suitable storage tank.

D.1.7 Organic Treatment Bulk Solids Unloading Area

The Organic Treatment Bulk Solids Unloading Area will be located to the southwest of the Bulk Solids Handling Area and the Kiln Feed Area (see Figure D-1-1). There will be three unloading bays available for transferring bulk solids into three concrete tanks located in the enclosed Bulk Solids Handling Area. The paved unloading area will be curbed to prevent rainwater run-on. The concrete base will slope towards a trench covered with a grating located along the wall of the Handling Area. The trench will slope into a sump at one end. The design of the Unloading Area is similar to other areas such as the Organic Treatment Container Truck Unloading Area. See Appendix D-5, Drawings 8813-00-S-008 and S-009 for the design details of the secondary containment system and foundation of the area. Even though ~~since~~ this area will not handle liquid wastes, secondary containment calculations are provided in Appendix D-2 ~~not included in this Permit Application~~. Any spilled solid waste can be washed to the trench and from there be transferred by a vacuum tank truck to a suitable hazardous waste tank. The area immediately in front of the roll doors will be covered. Motorized roll doors will provide access for transferring the solids into the Handling Area.

D.1.8 Inorganic Treatment Non-Pumpable Waste Truck Unloading Area

The Non-Pumpable Waste Truck Unloading Area will be located in the southwest corner of the FFP-LP facility as shown in Figure D-1-1. There will be two unloading bays available for transferring inorganic bulk solids into the acidic/alkaline dissolving tanks located in a building designated as the Non-Pumpable Waste Handling Area.

Each paved unloading bay will slope towards a trench which will drain into a sump on the end of the Truck Unloading Area adjacent to the Handling

D.3 CONTAINER STAGING AND PROCESSING AREAS

The next group of areas encountered in the normal operational flow of wastes through the FFP-LP facility are the two buildings where container staging and processing will occur. Both these buildings will be located close to the respective treatment units they are associated with.

D.3.1 Organic Container Staging and Processing Areas

This sub-section describes the Container Staging Area and the Container Processing Area for wastes intended for incineration at FFP-LP. The information provided is given in accordance with 40 CFR 270.15.

D.3.1.1 Structural Design and Capacity

A covered building will enclose the Organic Treatment Container Staging Area as shown on Figure D-1-1. The building's roof will prevent rainwater accumulation. The entire Staging Area floor will be at or above grade and will be surrounded by a concrete curb with a minimum height of 6 inches to prevent rainwater run-on and provide containment. The building floor will be constructed as a continuous reinforced concrete pad with sealed expansion joints and coated with a chemical-resistant and compatible sealer such as Ceilcrete epoxy coating or an equivalent, in accordance with 40 CFR 264.175. The specifications of a typical coating is provided in Appendix D-4. The base will be inspected according to Inspection Plan (Appendix F) to verify that it is free of significant cracks or gaps. The 6-inch curb throughout this Staging Area will be constructed as one unit contiguous with the floor. The section of the Staging Area's floor space devoted to drum acceptance and intermediate staging of drums and containers will encompass 6020 ~~4320~~ ft^2.

The building will be segregated into two four operational areas: container staging and container processing. Container unloading/intermediate staging, container staging, container emptying and kiln feed preparation. Truck unloading, intermediate staging, container emptying and kiln feed preparation areas are part of the container processing area. The design details of the secondary containment system and foundation of the building are shown in Appendix D-5, Drawings 8813-00-M-015.1, M-015.2, M-016, and S-005.

There will be a total of eight (8) containment bays in the Organic Treatment Container Building. The organic container treatment staging area, Drawing 8813-00-M-015.2, consists of six (6) containment bays. The organic treatment container processing area, Drawing 8813-00-M-015.1, consists of two (2) containment bays. The 12-foot wide main aisle along the high point of the concrete base will divide the building into two halves. The two halves which are separated from each other by the high point of the concrete base will be further divided into 4 areas each by 6-inch curbs, in accordance with 40 CFR 264.177(c). The concrete base will slope approximately 0.02 feet per foot toward trenches which drain into individual sumps. Container staging will occur in six areas. Containers will normally be staged in one of six containment bays (Drawing 8813-00-M-015.2). There will also be one containment bay for miscellaneous/ intermediate staging storage and one bay around the drum emptying station used for container processing (Drawing 8813-00-M-015.1).

The Staging Area will have a capacity of 380,160 gallons in 6,912 double-stacked, 55-gallon drums, or the equivalent volume in containers of other shapes and sizes. The capacity of container storage will be limited by the floor space of the proposed Staging Area. The containment calculations presented in Appendix D-2 (sheet 6 of 11) show that the volume of liquid which the individual secondary containment areas in the Staging Area can handle will be greater than 10% of the maximum volume stored in containers. The secondary containment system for the container emptying station will adequately handle the volume of the drummed pumpable waste receiver containerized waste receiving tank (bulking tank) located there. The design details of the waste receiving tank are provided in Appendix D-3. The provision of the various features of the containment system, including the sloping impervious base, curbs, trenches, and sumps, is designed to meet the requirements of 40 CFR 264.175.

The building will be provided with an automatic water or foam sprinkler system for fire protection. In addition, several fire extinguishers will be mounted in the building. The nearest property line to the Container Building lies more than 50 ~~200~~ feet away in any direction as shown in Figure D-1-1, in accordance with 40 CFR 264.176.

D.3.1.2 Management Of Wastes

All personnel working in this building will be thoroughly trained in the safe handling of containers and emergency response procedures to minimize the possibility of a container rupture or spill, in accordance with 40 CFR 264.173(b).

Qualified FFP-LP personnel will operate forklifts to transport the containers from the adjacent Truck Unloading Area to the miscellaneous/intermediate storage area where each container will be assigned an inventory number. This inventory number will be marked on the top and side of the drum or container just above the waste label. An inventory log shown in Figure D-3-1 will be used to record inventory log numbers and other descriptive information concerning the container contents.

This numbering code will be utilized from the first delivery to the final delivery at the facility. This numbering system will provide on-the-spot recognition of the generator location, waste characteristics, duration in storage, and a reference to analysis reports for a particular container. Once all containers have been off-loaded and numbered, staging area personnel will double check the entries in the inventory log against markings on containers to ensure that the correct numerical designation has been given. The log will be signed by the Drum Receiving/Unloading Workers after this check.

Figure D-3-1
Waste Container Inventory Log

1. Inventory No. ________ - _____-_____ - ________
(generator) (stream I.D.) (drum no.)

2. Manifest No. ______________________________

3. Truck I.D. No. ___________________________

4. Manifest Review: Accept ___________ Discrepancy ___________
(initial) (initial)

5. Type of Container (check one)

		Size	Type (circle one)
	________	X 85 Gallon	polyethylene, steel
	________	X 55 Gallon	polyethylene, steel, fiber
	________	X 30 Gallon	polyethylene, steel, fiber
Other: ______________	________	X __ Gallon	

6. Condition of Container: # (check one)

#		
_____	_____	Satisfactory
_____	_____	Leaking
_____	_____	Requires repackaging or emptying
_____	_____	Requires over-pack
_____	_____	Other (explain on back)

7. Labels:

A. DOT
- _____ ~~Compressed Gas~~
- _____ Flammable Liquid
- _____ Flammable Solid
- _____ Oxidizer/or Organic Peroxide
- _____ Poison
- _____ Corrosive
- _____ ORM
- _____ None
- _____ Other: ___________

B. EPA
- _____ Hazardous Waste
- _____ Hazardous Waste Solid N.O.S.
- _____ Hazardous Waste Liquid N.O.S.
- _____ Non-Hazardous Waste
- _____ Non-Regulated Waste
- _____ None

If any containers are received in a damaged or bad condition, or if they begin to leak, FFP-LP personnel will transfer the contents of the containers into overpack drums. A notation will be made in the Container Inventory Log to identify the condition and management of the faulty container, in accordance with 40 CFR 264.171. The replacement containers will be made of or lined with materials similar to that of the original containers, to ensure compatibility with the wastes, as required by 40 CFR 264.172. If necessary, pre-acceptance data and waste receipt analyses will be used to further confirm such compatibility.

In the meantime, the on-site laboratory will be used for analysis of container samples and reporting of results as described in the Waste Analysis Plan in Appendix C. Once results from fingerprint analyses of the waste shipment are reported and the inventory number is assigned to a drum, the drum (or a whole pallet) will be moved to one of the six containment bays of the Staging Area. A containment bay with compatible waste will be chosen. The containers stored in this Staging Area may hold any of the wastes listed in Section C (Waste Characteristics) of this permit application.

Pallets of four or less containers will be stored in single rows with a 3-foot aisle space between rows, a 4-foot aisle space segmenting the rows, and a 3 ~~2~~-foot aisle space between curbs and pallets. The aisle spacing will provide ease of movement and access for inspection, and drums will be positioned so that labels and markings are in full view from the aisle.

Containers in storage will be kept shut at all times except for occasional brief sampling periods or for immediate processing, as specified in 40 CFR 264.173(a). Under normal operation, drums will be single or double stacked. On occasion, however, smaller drums and containers may be stacked more than two tiers high. In any case, total stacking height will not exceed the guideline established by NFPA 30, "Flammable and Combustible Liquids Code."

Containers located beside curbs ~~will~~ may be double ~~single~~ stacked ~~particularly when the aisle space between curbs and pallets of drums in narrower than three and a hold feet (which is the height of a typical drum~~. The curbs will be equipped with eight foot tall chain link fences to prevent toppling of containers cross curbs into another bay. Containers on pallets that are more than three and a half feet (which is the height of the typical drum) away from curbs or edges of bays may be double stacked, since the distance will provide a buffer zone which will be sufficient to contain any toppled containers within the same bay.

Keeping containers closed during storage will prevent accidental ignition of flammable waste. Moreover, smoking, open flames, cutting and welding, and any other process which may generate heat or sparks will be prohibited in the entire Staging Area. Any necessary construction and maintenance activities will be conducted in accordance with the applicable facility health and safety procedures.

Inspections to ensure the integrity of the stored containers and the Staging Area, and to detect accumulated liquids will be conducted in accordance with the Inspection Plan, to comply with 40 CFR 264.171 and 264.174. Containers found to be leaking will be removed and emptied, repackaged, or placed in properly marked over-pack drums. Normally, the containers will be stored on wooden pallets which will keep the containers from being in direct contact with any accumulated liquid, in accordance with 40 CFR 264.175(c)(2).

In the event of leaks or spills from a container or containers in the Staging Area, immediate response will be initiated pursuant to the facility emergency response procedures outlined in the Contingency Plan (Section G). All reasonable efforts will be made to identify the source of the discharge to stop the problem and prevent future recurrences. If necessary, e.g., when the characteristics of the wastes cannot be identified, a representative sample may be taken from the sump and expedited through the on-site laboratory analytical screening process to determine the chemical characteristics of the discharge. The time between sampling and resultant analyses will be spent controlling and containing the discharge following the most stringent precautions suitable for the waste type designated for that particular containment area. In any case, all accumulated liquids will be transferred in a timely manner by vacuum trucks to an appropriate "organic" waste storage tank or directly incinerated, in accordance with 40 CFR 264.175(b)(5).

The containers will be prepared for incineration in the Container Processing Area located adjacent to the Staging Area within the same building. This Processing Area will be segregated from the Staging Area by an enclosure to maintain safety and personnel protection in the Staging Area while the containers are being pumped, shredded, or fed directly into the incinerator. Fugitive emissions in this enclosure will be vented to the incinerator as combustion air, or to the atmosphere via carbon adsorption beds.

A jib crane will handle and place containers on a conveyor to be transferred into the enclosed container emptying station where the liquids will be pumped out. Vapors from the enclosed container emptying station will be exhausted through the emission control system. An emptying pump will transfer the contents of the containers to a ~~containerised~~ drummed pumpable waste receiver ~~receiving~~ tank (listed in Table D-4-1 in Section D.4.1, and shown in the tank design drawings in Appendix D-3) from which the liquids will be fed into the incinerator. The empty containers and un-reusable pallets will be transferred to the shredder and subsequently to the shredded material tank in the adjacent Bulk Solids Handling Area. Containers of solids may be directly conveyed, without being emptied, to the kiln feed to be incinerated.

stacked. On occasion, however, ~~smaller~~ drums and containers smaller than 55-gallon capacity may be stacked more than two tiers high within the limits set by NFPA 30 guidelines.

Containers located beside curbs will be double ~~single~~ stacked ~~particularly when the aisle space between curbs and pallets of drums is narrower than 3½ feet (which is the height of the typical drum.)~~ The curbs will be equipped with eight foot tall chain link fences to prevent toppling of containers across curbs into another bay. Containers on pallets that are more than three and a half feet away from curbs or edges of bays may be double stacked, since the distance will provide a buffer zone which will be sufficient to contain any toppled containers within the same bay.

Inspections of the condition of the stored containers and the Staging Area will be conducted in accordance with the Inspection Plan, to comply with 40 CFR 264.174. In the event of a discharge of free-flowing liquid from containers in the Staging Area, immediate response will be initiated pursuant to the facility emergency response procedures outlined in the Contingency Plan (Section G). All reasonable efforts will be made to manage the discharge according to the procedures in Section D.3.1.2.

Inspections to detect any accumulated liquids will be made regularly, according to the Inspection Plan (Appendix F). Liquid which is collected in the sumps will be removed promptly by use of a vacuum tank truck and placed in an appropriate inorganic waste storage tank or directly fed into the inorganic treatment system, in accordance with 40 CFR 264.175(b)(5). Containers found to be leaking will be removed and emptied, repackaged or placed in properly marked overpack drums. Normally, the containers will be stored on wooden pallets which will keep the containers from being in direct contact with any accumulated liquid, in accordance with 40 CFR 264.175(c)(2).

Pumpable wastes will be pumped out of containers in the Container Processing Area. This area will consist of two separate container emptying stations. One station will be used for alkaline/cyanide-containing waste and the other for acidic/non-cyanide waste.

Each drum emptying station in the Processing Area has adequate space to accommodate three pallets of drums (i.e. 660 gallons, the equivalent of 12 55-gallon drums) for emptying. The contents of the drum will be pumped to the waste receiving tank (listed in Table D-4-3 in Section D.4.2 and shown in the tank design drawings in Appendix D-3) via the container emptying pump. To avoid hazards from vapors escaping the drum being emptied, the operator will open the containers underneath a ventilation hood so that all vapors are vented to the emission control systems.

The most important safety aspect in the inorganic treatment process is to ensure that acidic and alkaline waste are not mixed together unintentionally. There will be continuous, interlocked monitoring of the pH of the waste at the container emptying pump. If the operator attempts to pump an acidic waste into the alkaline waste receiving tank (or vice versa), an alarm for low pH will sound and the automatic block valve on the inlet of the receiving tank will close.

Empty drums will either be re-used or ~~taken to the Organic Treatment Container Processing Area, where they will be shredded and then inceneratаed~~ properly disposed of offsite. Empty pallets will be stacked in an appointed area of the Inorganic Treatment Container Staging Area for later re-use. These pallets will be of a construction suitable to support the anticipated drum weight.

Drums and pallets will be re-used if it is determined that these items are uncontaminated with hazardous wastes. For example, drums and pallets used for reagent chemicals used for inorganic treatment may be re-used for the same chemicals. Drums and pallets contaminated by wastes or otherwise unacceptable for re-use (e.g., loss of structural integrity) in the inorganic treatment area will be ~~taken to the organic treatment area to be shredded for incineration~~ properly disposed of offsite.

Drums to be re-used at the facility will include those that previously contained hazardous waste, as well as those that contained chemical products used at the facility. Any drum that had contained hazardous waste will be triple rinsed with an appropriate rinsing agent, prior to reuse. Drums containing product will be used to store compatible waste (e.g. laboratory waste) or triple rinsed with an appropriate rinsing agent, prior to storing other wastes. Pallets will be reused if they are free of spills. Those contaminated from spills will be incinerated and in some cases rinsed (with an appropriate agent) prior to introduction into the kiln.

Empty drums will not be stored for any significant time, and will be kept shut, minimizing the potential of hazardous air emissions. Furthermore, the drums will be stored in an area that is vented to the inorganic treatment emission control system.

The Organic Treatment Pumpable Waste Storage Area will receive pumpable waste directly from railroad tank cars, tank trucks, and vacuum tank trucks (containing liquids collected from sumps on the site) docked at the Tank Truck Unloading Area and Railroad Tank Car Unloading Area. The Organic Treatment Pumpable Waste Storage Area will also receive pumpable waste from the Containerized Waste Receiving Tank in the Organic Treatment Container Processing Area. The Inorganic Treatment Pumpable Waste Storage Area will receive pumpable waste from tank trucks, railroad tank cars, and vacuum tank trucks (containing liquids collected from sumps on the site). The inorganic waste tanks will also receive pumpable waste from the Containerized Waste Receiving Tanks in the Inorganic Treatment Container Processing Area.

The design of the secondary containment systems provided for all storage and process tanks at the facility is described below. Relevant secondary containment calculations to demonstrate adequate containment capacity are provided in Appendix D-2. Also included in Appendix D-2 are the tank pinhole calculations used to determine the length of asphalt pavement extended beyond the secondary containment curbs which will adequately prevent soil or groundwater contamination due to any tank leaks.

D.4.1 Organic Treatment Pumpable Waste Storage Area

The Organic Treatment Pumpable Waste Storage Area is shown in Figure D-1-1. A summary of hazardous waste storage and process tanks in the Organic Treatment Pumpable Waste Storage Area and other areas associated with the incinerator system is presented in Table D-4-1. The hazardous waste liquid storage tanks will consist of one 2,000-gallon, ten 19,500 ~~20,000~~-gallon, and one 8,000-gallon carbon-steel, above-ground, vertical, fixed-roof tanks. In addition, one non-RCRA regulated 19,500 ~~20,000~~-gallon tank will be used to store fuel.

oil. The solid waste storage/processing tanks will be located in the Bulk Solids Handling Area described in Section D.5.1. The containerized waste receiving tank will be located in the Container Building described in Section D.3.1. The liquid storage tanks will be constructed on leg supports with dished roofs and conical or dished bottoms. The leg supports will allow easy access for tank integrity inspections as prescribed in the Inspection Plan (Appendix F).

D.4.1.1 Design

The tank design drawings in Appendix D-3 show the wall thickness, dimensions, number of legs, construction material, corrosion allowance and capacity for each hazardous waste tank (excluding the non-RCRA regulated Fuel Oil Tank).

Tank Design Specifications

Tanks to be constructed at FFP-LP will meet the design standards of the American Petroleum Institute (API) and other organizations listed in Table D-4-2, as appropriate. In addition, the detailed tank design will be reviewed and certified by an independent, qualified, professional engineer registered in the state of Florida.

Piping used in the transfer of wastes into, among, and from the tanks to the incinerator will be made of carbon steel. Indicators, sensors, controllers, motors, valve operators and wiring will be specified in accordance with accepted practices and standards of the petrochemical industry for similar applications.

TABLE D-4-2

APPLICABLE CODES FOR TANK CONSTRUCTION

Code	Section/Part	Application/Title
API Std. 620, 7th Edition, 1982	Section 3	Welding Requirements
API Std. 620, 7th Edition, 1982	-	Low-pressure Storage Tanks
ACI 318-83	-	Tank Foundation Design
API Std. 2000 3rd Edition, 1982	-	Venting Low-pressure Storage Tanks
ASHRAE*	Industrial	Industrial Ventilation and Vapor Control
NFPA	30 - 1984	Fire Protection, Vents, Drains, Dike Construction
29 CFR-85	Part 1910	Occupational Safety and Health Standards
ANSI/ASME B31-1-86	-	Chemical Plant and Refinery Piping
SBCCI-88	Section 1205	Wind Loads
FM	7-88	Flammable/Combustible Liquid
ANSI 58.1-82	Section 9	Seismic Loads
ACI 318-83	-	Bulk Solids Concrete Tanks
NBS-PS 15-69	-	Fiberglass Reinforced Plastic Tanks

* American Society of Heating, Refrigerating and Air Conditioning Engineers

Operating Pressure

The hazardous waste storage tanks are designed to operate between 4" and 18" wc (water column) through the use of a pressure/vacuum relief system. A 4" wc nitrogen pad will be maintained on each tank for inerting and vacuum relief. Vapors from these tanks will pass through the emission control system described at the end of Section D.4.1.2.

During filling operations, vapors will be displaced through the pressure control valve which has a normal (i.e. handling tank breathing and working losses) pressure relief set at approximately 18" wc. During ~~normal~~ routine emptying operations, nitrogen will be introduced to equalize the tank pressure at 4" wc.

Tank Corrosion and Erosion

Tank corrosion allowance is shown on the tank design drawings in Appendix D-3. Tank construction materials have been carefully selected considering compatibility with the types of wastes to be managed, using standard charts which identify the compatibility of fluids, seals/lines, and construction materials such as those found in Emco Wheaton Inc., "Loading Arm Assemblies," 1974.

Incoming wastes will be inspected and analyzed as set forth in the Waste Analysis Plan (Appendix C). Based on analytical results and other waste information, appropriate waste storage tanks will be identified. The waste information and operating records will be used to ensure that the waste placed in any tank is (1) compatible with the waste currently or previously contained in the vessel, (2) compatible with the construction material of the tank, and (3) within the specific gravity limits specified by the tank design drawings.

FFP-LP will conduct annual nondestructive testing using ultrasonic tank shell thickness testing or equivalent and applicable methods such as those referenced in American Society of Mechanical Engineers (ASME), "Boiler and Pressure Vessel Code," to verify the continuing structural integrity of facility tanks. Equipment used include resonance or pulse-type ultrasonic instruments, as described in New York Department of Environmental Conservation, "Technology for the Storage of Hazardous Liquids." Testing will be conducted on the same locations on the tank shells from year to year to observe predictive trends. Any tank with a shell thickness that critically approaches the established minimum shell thickness will be taken out of service according to applicable ASME standards and the approved Closure Plan (Appendix I-1). This annual structural integrity testing will the conducted in addition to the daily visual inspections, as outlined in the Inspection Plan (Appendix F).

Emission Control System

The vent line of each hazardous waste tank will be connected to a common header pipe which will route the vapors to the incinerator as combustion air. If the incinerator is not in operation, the vapors will be routed through a two stage mechanical chiller and then through two of four activated carbon adsorbers before being released to the atmosphere. Each carbon bed will measure approximately two feet in diameter and three feet in height. The carbon beds will be inspected for breakthrough of volatile organics in accordance with the Inspection Plan (Appendix F).

Secondary Containment Design

Secondary containment will be provided for at least the volume of the largest tank. Each segregated containment area is limited to a few tanks to

264.198(b), the Storage Area will be located more than 50 ~~200~~ feet away from the facility property line to maintain protective distances between the waste management area and the public.

D.4.2 Inorganic Treatment Pumpable Waste Storage Area

The Inorganic Treatment Pumpable Waste Storage Area used to store bulk liquid inorganic wastes as shown in Figure D-1-1. A summary of hazardous waste storage and process tanks in the Inorganic Treatment Pumpable Waste Storage Area and other areas associated with the Inorganic Treatment System is presented in Table D-4-3. The hazardous waste storage tanks will consist of twenty-two 8,000-gallon, two 25,000 gallon, ~~and~~ two 2,000-gallon vertical, and one 240,000-gallon, above-ground, fixed-roof, fiber glass-reinforced plastic (FRP) tanks, ~~and two 8,000-gallon, two 25,000-gallon,~~ and two 5,000-gallon vertical, above-ground, fixed-roof, lined carbon steel tanks. The Dried Solids System will utilize another three lined-carbon steel silos and tanks. An additional three 8,000-gallon and two 1000 gallon FRP storage tanks will hold non-RCRA regulated process chemicals which are presented in Table D-4-4 ~~not further addressed in this permit application~~. The tanks will be constructed on leg supports with dished roofs and bottoms. The 240,000-gallon tank will be constructed on an I-beam support structure. The leg supports will allow easy access for tank integrity inspections as prescribed in the Inspection Plan (Appendix F). Process units that are not considered tanks are presented in Table D-4-5.

D.4.2.1 Design

The tank design drawings in Appendix D-3 show the wall thickness, dimensions, number of legs, construction material, corrosion allowance, and capacity for each hazardous waste tank (excluding the non-RCRA regulated Reagent Storage Tanks).

Tank Design Specifications

Tanks and process units to be constructed at FFP-LP will meet the design standards of the American Petroleum Institute (API) and other organizations as listed Table D-4-2, as appropriate. In addition, the detailed tank design will be reviewed and certified by an independent, qualified, Florida registered, professional engineer.

Piping used in the transfer of wastes into, among, and from the tanks to the reactors will be made of fiberglass-reinforced plastic (FRP). Indicators, sensors, controllers, motors, valve operators, and wiring will be specified in accordance with accepted practices and standards of the petrochemical industry for similar applications.

Operating Pressure

The inorganic hazardous waste storage tanks are designed to operate between -4" and 8" wc (water column) through the use of a negative pressure/vacuum relief system. Since the contents of the tanks associated with the inorganic treatment system are not ignitable, a nitrogen pad will not be needed in the tanks.

Tank Corrosion and Erosion

Tank corrosion allowance is shown on the tank data sheets ~~design drawings~~ in Appendix D-3. Tank construction materials have been carefully selected considering compatibility with the types of wastes to be managed, using standard charts which identify the compatibility of fluids, seals/lines, and construction materials such as those found in Emco Wheaton Inc., "Loading Arm Assemblies," 1974.

Incoming wastes will be inspected and analyzed as set forth in the Waste Analysis Plan (Appendix C). Based on analytical results and other waste information, appropriate waste storage tanks will be identified. The waste information and operating records will be used to ensure that the waste placed in any tank is (1) compatible with the waste currently or previously contained in the vessel, (2) compatible with the construction material of the tank, and (3) within the specific gravity specified by the tank design drawings.

FFP-LP will conduct annual nondestructive testing using ultrasonic tank shell thickness testing or equivalent and applicable methods such as those referenced in American Society of Mechanical Engineers (ASME), "Boiler and Pressure Vessel Code," to verify the continuing structural integrity of facility tanks. Equipment used include resonance or pulse-type ultrasonic instruments, as described in New York Department of Environmental Conservation, "Technology for the Storage of Hazardous Liquids." Testing will be conducted on the same locations on the tank shells from year to year to observe predictive trends. Any tank with a shell thickness that critically approaches the established minimum shell thickness will be taken out of service according to applicable ASME standards and the approved Closure Plan (Appendix I-1). This annual structural integrity testing will the conducted in addition to the daily visual inspections, as outlined in the Inspection Plan (Appendix F).

Emission Control System

The vent line of each hazardous waste tank will be connected to a common header pipe which will route the vapors to the Inorganic Emissions Control Scrubber, ID fans and stack. These ~~incinerator, or (when the incinerator is not operating) to an activated carbon adsorption bed which~~ will be inspected regularly in accordance with the Inspection Plan (Appendix F).

Secondary Containment Design

The capacity of the secondary containment system will be greater than the volume of the largest tank. Each of the four inorganic waste groups will have its own containment area in the Storage Area. All pumps and piping to be utilized for waste transfer will also be visually inspected for leaks on a daily basis, in accordance with the Inspection Plan (Appendix F). Hence, the piping need not have secondary containment as allowed for by 40 CFR 264.193(f). Since the Inorganic Treatment Pumpable Waste Storage Area will be covered, rainfall from a 25-year, 24-hour storm will not enter the secondary containment areas and is not accounted for in the containment calculations. The curbed concrete-paved containment areas will also prevent rainwater run-on. The floor of the containment areas will slope at approximately 0.02 feet per foot to trenches which drain into sumps to collect any accumulated liquids. The floor and sumps will be coated with a chemical-resistant and compatible sealer such as the epoxy specified in Appendix D-4. Inspections to detect any accumulated liquids will be made regularly in accordance with the Inspection Plan (Appendix F). Wastes which may collect in the sumps will be promptly removed with a vacuum tank truck or similar system. Secondary containment system and foundation design details are presented in Appendix D-5, Drawing 8813-00-M-030, S-030, and S-031. Secondary containment calculations for all hazardous waste tanks are presented in Appendix D-2 (sheets 1 and 2 of 9).

D.4.2.2 Management of Wastes

The Waste Inventory System to be used to track the inorganic wastes through the facility is similar to that used for the tanks associated with the incinerator system, as described in Section D.4.1.2. Information on the necessary control and monitoring of the hazardous waste storage tanks is provided in Section D.4.1.2 (i.e., Overfill and Spill Control) and P&IDs contained in Appendix D-5. Management of reactive wastes stored in tanks is addressed below.

Reactive Wastes

Reactive wastes will be placed in storage tanks in strict accordance with procedures outlined in the Waste Analysis Plan. Reactive wastes will be segregated from wastes or other materials which could initiate uncontrolled reactions. The information needed for ensuring that incompatible wastes are not mixed will be readily available from the waste inventory system described in Section D.4.1.2, pre-acceptance waste characterization data, and waste receipt analyses.

D.4.3 Reagent Storage Area

Reagents to be used in the inorganic treatment system will be stored at the Reagent Storage Area located to the east of the Inorganic Reactor Tank Area where the treatment processes will occur. This Storage Area, as with other storage areas, will be covered to keep out the rain and ultraviolet radiation from the sun. There will be three separately contained tanks dedicated to the storage of sodium hypochlorite, sodium bisulfite, and sulfuric acid. The design of this Storage Area is given in Appendix D-5, Drawing 8813-00-M-033. Even though this Storage Area will only store process chemicals and will not be regulated under RCRA, secondary containment calculations are provided as reference in Appendix D-2 (sheet 8 of 9).

enough space both for inspection and for pumping out any leakage. See Appendix D-5, Drawings 8813-00-M-017, S-008, and S-009 for design details of this Handling Area's secondary containment system and foundation. Even though ~~Since~~ this area will not manage liquids, secondary containment calculations are included in Appendix D-2 ~~not provided~~. If necessary, the Paint Filter Test referenced in the Waste Analysis Plan (Appendix C) may be used to confirm the absence of free liquids in the wastes stored in this area.

The nearest property line to the bulk solids storage tanks lies more than 100 feet away, in accordance with 40 CFR 264.198(b). The area will be provided with an automatic fire detection/protection system. In addition, several fire extinguishers will be mounted nearby. To prevent accidental ignition of ignitable wastes, smoking, or any activities that will generate heat or sparks will be prohibited in the Bulk Solids Handling Area under normal operation. Any necessary construction and maintenance activities in the building will be conducted in accordance with applicable facility health and safety procedures.

The bulk solids storage tanks will be inspected in accordance with the Inspection Plan (Appendix F).

D.5.2 Inorganic Treatment Non-Pumpable Waste Handling Area

Inorganic non-pumpable waste will arrive at the facility in dumpsters or vacuum tank trucks. The waste will be transferred into one of the waste receiving hoppers at the two bulk solids receiving stations, according to compatibility. These hoppers will feed the waste directly into dissolving tanks equipped with agitators to mix the waste up into more workable slurries. Transfer pumps will then be used to move the waste into two dissolved waste holding tanks while awaiting future processing in the inorganic treatment system. The tanks to be used in this Handling Area are noted in Table D-4-3 in Section D.4.2 and shown in the tank data sheets in Appendix D-3.

Each set of process equipment comprising of a receiving chute ~~hopper~~, dissolving tank, and dissolved waste holding tank, will be provided with segregated secondary containment to sufficiently handle the volume of the largest tank, i.e., the holding tank. The secondary containment system will include sloped and curbed concrete bases, trenches, and sumps, as shown in Appendix D-5, Drawing 8813-00-M-031. The bases, trenches and sumps will be coated with a chemical-resistant and compatible sealer such as the epoxy specified in Appendix D-4. The features of the foundation of the base are shown in Appendix D-5, Drawing 8813-00-S-032 and S-033. Secondary containment calculations are provided in Appendix D-2 (sheet 3 of 9).

referenced in the Waste Analysis Plan (Appendix C) may be used to confirm the absence of free liquids in the wastes stored in this area. Since free liquids will be stored in this area, secondary containment calculations are not included in this permit application.

The base underlying the containers will be coated with an impervious and waste-compatible substance to contain any leaks or spills. The base will slope approximately 0.02 feet per foot towards a similarly coated sump to facilitate washdown and cleanup of wastes. The specifications of a typical coating is provided in Appendix D-4. Details of this area are shown in Appendix D-5, Drawings 8813-00-M-026 and S-011. Accumulated wastes will be promptly removed from the sump by a vacuum tank truck and placed in an appropriate storage tank. The Loadout Area will be inspected in accordance with the Inspection Plan (Appendix F).

D.6.4 Lime Unload Area

The Lime Unload Area will be located adjacent to the Spray Dryer Absorber (part of the incinerator pollution control system) as shown in Figure D-1-1. A reinforced concrete slab will serve as an unload area for the lime used in the Spray Dryer Absorber and a loadout/holding area for grit coming off of the fine mesh screens included in the recycled dried solids system. This grit which contains unreacted lime will be re-introduced into the Spray Dryer Absorber to more completely use the lime. A more detailed description of the lime reagent system is provided in Section D.7. Since this area will only hold lime (non-RCRA reagent) and recyclable lime (recycled dried solids), and will not be regulated under RCRA, further details are not included in this permit application.

Appendix D-5, Drawings 8813-00-M-034 and S-034. Accumulated wastes will be promptly removed from the sump and placed in an appropriate storage tank. The Loadout Area will be inspected in accordance with the Inspection Plan (Appendix F).

D.6.6 Residue Storage Areas

The Residue Storage Areas are both shown in Figure D-1-1. The Residue Storage Areas will be constructed at the facility to receive and store residue wastes in 6 yd^3 containers as well as bulk solids wastes in lugger boxes. Each of these areas will have the capacity to store 1292 6 yd^3 containers. Secondary containment will be provided for each area as required by 40 CFR 264.175(b)(3) and will contain approximately 776 yd^3 or 10% of the maximum storage capacity.

Each area will be provided with a roof to minimize rainwater accumulation and curbs to prevent rainwater run-on. Although no free liquid will be present in the containers in these areas, secondary containment will be provided as discussed in previous sub-sections. The base underlying the containers will be coated with an impervious and waste-compatible substance to contain any leaks or spills. The base will slope approximately 0.02 feet per foot towards a similarly coated sump to facilitate washdown and cleanup of wastes. The specifications of a typical coating is provided in Appendix D-4. Secondary containment calculations are be included in Appendix D-2 (sheet 11 of 11). Secondary containment system and foundation details of this area are shown in Appendix D-5, Drawings 8813-00-M-022, M-023, and S-013.

Accumulated wastes will be promptly removed from the sump by a vacuum tank truck and appropriately managed on-site or off-site. If necessary, e.g., when the characteristics of the wastes cannot be identified, a representative sample may be taken from the sump and expedited through the on-site laboratory

[Section D.7 has been revised in its entirety]

D.7 Engineering Description of Incinerator

The incinerator system is shown in Figure D-1-1. The information in this section is presented in accordance with 40 CFR 264 Subpart O.

D.7.1 Process Description

The following section is intended to supplement drawings in Appendix D-5 in depicting an overview of the process, and to provide a more detailed description of the equipment given in the next section.

The incineration system to be installed at the FFP-LP Facility will consist of a rotary kiln with a secondary combustion chamber (SCC) and dry scrubbing air pollution control equipment (APCE) utilizing a spray dryer absorber (SDA) and fabric filter.

Liquid wastes to be fed to the system will be stored in tanks located near the combustion train. The kiln will be equipped with specialized feeders for bulk solids, containerized waste, four nozzles for sludge and low-Btu liquids, and a burner for auxiliary fuel or high-Btu liquid. The SCC will be equipped with three burners for auxiliary fuel or high-Btu liquid and one nozzle for low-Btu liquid.

The combustion gases from the kiln will pass through a transition chamber and into the bottom of the SCC where high-Btu liquid and/or auxiliary fuel will be burned to complete the combustion process. The manner of entry of the gases into the SCC, along with the placement of the burners, is designed to generate significant turbulence throughout the chamber, and, in combination with the more than two seconds of gas residence time under normal operations, to ensure complete combustion of any remaining organics. The combustion gases from the SCC will pass through the SDA and fabric filter before being discharged through the stack via two parallel induced draft (ID) fans.

Ash and incinerated solids will be discharged from the kiln through the transition chamber to a wet ash collection system where the ash will be cooled in water. The ash, which will discharge into a lugger box, will be cooled and wetted for dust-free handling during disposal. Dried solids from the APCE will be transferred to a solids recycle silo or solids storage silo by enclosed drag conveyors for recycle or discharge to a lugger box.

D.7.2 Equipment Description

D.7.2.1 Incineration System

General

This section describes in detail the components of the incineration system and its design. Typical manufacturers and model numbers for major equipment components are referred to herein. These are only to be considered as representative examples. The equipment named is, however, capable of meeting the required performance standards.

Drawing 8813-00-F-001 (Appendix D-5) is a block flow diagram of the incineration system. Drawings 8813-00-M-018 through 8813-00-M-021 (Appendix D-5) are general arrangement drawings which provide a conceptual view of the incineration system. Table D-7-1 provides a quick-reference guide to the major features of the incineration system.

Rotary Kiln

The inside diameter (ID) of the kiln's welded, carbon-steel shell will be 16'-3". The kiln will be encircled by two steel riding rings, each of which will rotate on a pair of steel trunnions. The girth-gear drive system will be powered by a variable-speed motor and gear reducer. It will be possible to vary the rotational speed of the kiln from a maximum rpm of 0.7 to a minimum of 0.1, and the slope of the kiln will be 2°. The solids residence time can therefore be varied from 20 to 140 minutes.

A single-speed AC motor and secondary gear reducer will be connected to the high-speed shaft of the main gear reducer by an overrunning clutch coupling. The input shaft of this slow-speed emergency drive will be fitted with a spring-loaded brake shoe so that it is not normally engaged.

Table D-7-1
Incinerator Specifications

Manufacturer	IWES	
Model Number	None; custom designed	
Type	Rotary kiln/SCC	
Dimensions:	Kiln:	14'-3" refractory ID x 39'-4" long 160-ft^2 cross-section 6,296-ft^3 volume
	SCC:	11'-0" refractory ID x 51'-7" long 95-ft^2 cross-section 4,903-ft^3 volume
Auxiliary fuel	No. 2 fuel oil. Combustion air from forced-draft blowers.	
Capacity of prime mover (Two ID fans)	Normal:	81,000 acfm @ 390°F
	Design Maximum:	90,000 acfm @ 390°F

Waste feed cut-off — All waste feed is cut off automatically under the following conditions:

- Power failure
- ID fan failure
- High SDA outlet temperature (500°F for 15 seconds)
- Rotary atomizer failure
- Loss of all SCC fuel oil flames
- High SCC temperature (2400°F for 15 seconds)
- High CO concentration (100 ppm average for 1 hour)
- High HCl concentration (100 ppm average for 1 hour)
- Low O_2 concentration (3% for 1 minute)
- High combustion gas flow (81,000 acfm @ 390°F for 15 sec.)
- Low fabric filter pressure drop (1" wc)
- High kiln pressure (-0.05" wc for 30 seconds)
- Low SCC temperature (1800°F)

Stack gas monitoring — O_2/CO/HCl/THC/opacity: continuous emissions monitoring system

Table D-7-1
Incinerator Specifications (Cont.)

Pollution control equipment	SDA and fabric filter
Nozzle and burner	Kiln: one 30 MM-Btu/hr North American Model No. 6385-14 Magna Flame burner (or equivalent); four Ripco Model LSA 125-45 or Model LSA 300-60R nozzles (or equivalent) SCC: three 13 MM-Btu/hr T-Thermal Model LV-13 high-intensity burners (or equivalent); one Ripco Model LSA 125-45 nozzle (or equivalent)
Construction materials	Combustion chambers: carbon-steel shell and high-alumina firebrick refractory SDA: carbon steel (refractory-lined gas inlet) Fabric filter: carbon steel with teflon-coated fiberglass or Gortex membrane bags ID fan: carbon steel Stack: carbon steel Waste feed tanks, pumps and piping: carbon steel
Location and description of temperature, pressure, and flow indicating and control devices	See Drawing 8813-00-F-17 for monitoring locations during the trial burn and subsequent operations.
Maximum combustion chamber heat release	Total: 75 MM Btu/hr Kiln: 75 MM Btu/hr SCC: 40 MM Btu/hr

The kiln feed hood, or faceplate, will be equipped with a burner, four waste nozzles, two turbulence air nozzles and a feed system for bulk solids and containerized waste.

The kiln seals will be a flexible stainless-steel system by Webbco Engineering Company, or equivalent. The system will comprise overlapping, adjustable, stainless-steel spring plates. The sealing edges of each plate, which will rest on the kiln shell, will be fitted with a sintered-metal wear shoe similar to a brake shoe. The powdered metal formulation for the seal shoes will contain graphite granules which make the shoes self-lubricating. The system will be installed at both ends of the kiln.

The kiln will be designed for a maximum heat release rate of 75 MM Btu/hr, and operation within 5% of this maximum rate will be demonstrated during trial burn Test 2, as illustrated in Table 1.7.1-1 of the Trial Burn Plan. The liquid burner is rated for a maximum heat release rate of 30 MM Btu/hr, as noted in Table D-7-1, Incinerator Specifications. The maximum heat release rate of the liquid burner of 30 MM Btu/hr does not include heat release through the waste feed nozzles or containerized waste and bulk solids feed systems, each of which provide additional heat release to the kiln. The total heat release rate from all waste and fuel feeds to the rotary kiln will not exceed 75 MM Btu/hr.

<u>Transition Chamber</u>

The transition chamber connecting the kiln and SCC will be designed in size to collect the ash discharge from the rotary kiln and to allow larger particulates to drop out of the gas stream prior to its entry into the bottom of the vertical, cylindrical SCC. Ash will discharge from the kiln and drop onto a submerged drag conveyor, where water will cool the solids before transfer to a lugger box for transport to off-site disposal. The conveyor water trough will be fabricated of epoxy-lined carbon steel, and the concrete-paved area surrounding it will provide secondary containment. Water will be purged from the trough to control dissolved and suspended solids.

SCC

Combustion gases from the kiln will enter the bottom of the vertical SCC through the refractory-lined transition chamber and exit near the top of the SCC through a refractory-lined duct to the SDA. The SCC will be equipped with three burners, one waste nozzle and one turbulence air nozzle mounted on the sidewall around the circumference of the chamber, near the bottom.

The entrance to the SCC will be designed with a significant reduction in area in order to increase the gas velocity and, in conjunction with the burners located immediately downstream, provide turbulence and mixing of the flue gases. This highly turbulent regime will ensure that virtually all combustion gases pass through the flame zone, where destruction efficiency is greatest. The burners, firing either high-Btu liquid or fuel oil will raise the temperature of the combustion gases to 1800°F-2200°F to complete combustion of residual organic vapors from the kiln.

The SCC diameter was chosen to maintain a high bulk gas velocity, and thus turbulence, throughout the chamber, even at the expected maximum turndown ratio. The requirement for at least two seconds of gas residence time in the SCC determined the chamber length. A high residence time in the post-flame zone under oxidative conditions, high temperature and high turbulence will ensure optimum destruction efficiency.

D.7.2.2 Manufacturer's Name and Model

The incinerator has been designed for FFP-LP by IWES. It is a custom-designed unit and has no model number.

D.7.2.3 Incinerator Type

The incinerator to be used at the FFP-LP Facility will be a rotary kiln incinerator with an SCC and dry scrubber APCE.

D.7.2.4 Linear Dimensions and Internal Cross-sectional Areas

The kiln shell will be approximately 16'-3" in inside diameter (ID) by 39'-4" long. It will be lined with 12" of refractory, giving a refractory ID of approximately 14'-3", a cross-sectional area of 160 ft^2, and an internal volume of 6,296 ft^3. The size of the kiln is shown in Appendix D-5, Drawing 8813-00-M-020.

A refractory-lined transition chamber will connect the kiln to the SCC. Its cross-sectional area will be greater than that of the kiln to reduce the gas velocity and to allow the larger ash particles to separate from the gas stream and to collect in the ash discharge.

The vertical, cylindrical SCC will have a welded, carbon-steel shell which has approximately a 12'-4" shell ID. It will be lined with 8" of refractory, giving an ID of 11'-0" and a cross-sectional area of 95 ft^2. With a 51'-7" effective length (the length used to calculate residence time), the effective volume of the SCC will be 4,903 ft^3, measured from the centerline of the burners to the centerline of the gas outlet thermocouples. The details of the SCC are shown in Appendix D-5, Drawings 8813-00-M-019 and 8813-00-M-020.

The SCC will be sized to provide at least two seconds of gas residence time at the maximum combustion gas flow (71,000 acfm at 390°F) for the total system 75 MM-Btu/hr heat release. At the 71,000-acfm stack gas flow, the SCC combustion gas flow would be approximately 118,500 acfm. Since the SCC effective volume will be 4,903 ft^3, this equates to 2.5 seconds of gas residence time.

D.7.2.5 Auxiliary Fuel System

The auxiliary fuel to be used will be No. 2 fuel oil containing less than 0.5% sulfur, 0.1% nitrogen and 0.2% ash. A 19,500-gallon storage tank will be provided for auxiliary fuel in the waste storage tank area. The fuel oil feed system will consist of two cast iron gear pumps, one of which will be on line and the other an installed spare. The estimated pump capacity will be 10 gpm at 40 psi.

Fuel oil will be delivered to the kiln and SCC via a recirculation loop with a back-pressure controller to maintain a constant feed pressure. The amount of fuel oil fed to the combustion chambers will be controlled by flow controllers set by the combustion temperature controller to maintain the required operating temperatures.

All burners will be supplied with a burner management system to control burner light-off, operation and shutdown. The system will be designed to control the system air purge cycle prior to burner ignition; control the lighting of the burners; and monitor the flame, combustion air pressure and fuel pressure. The burner management system will be interlocked to immediately close the fuel double-block valves if any unsafe system conditions occur.

In cases where only waste feed is shut off, auxiliary fuel will be used to automatically maintain the temperature of the combustion chambers until waste feed can resume.

D.7.2.6 Prime Mover (ID Fan) Capacity

The total capacity of the two parallel ID fans is estimated at 90,000 acfm at 390°F and 25"-wc differential. Each fan will provide 50% of the total capacity, will have radial-tip blades and will be of carbon-steel construction. The fans will also include a common inlet-volume-control damper. Each fan will be driven by a 300-hp motor. The fans will be sized to maintain a negative pressure throughout the system to prevent fugitive emissions. See Appendix D-4-8 for the manufacturer's capacity information.

D.7.2.7 Waste Feed and Waste Cutoff System Descriptions

There will be five major forms of hazardous waste feed:

- Containerized waste
- Bulk solids
- High-Btu liquid
- Low-Btu liquid
- Sludge

Low-Btu liquid wastes will be injected through the four kiln nozzles and the one SCC nozzle; sludge will be injected through the four kiln nozzles; high-Btu liquids will be delivered to the kiln and SCC burners; containerized waste will be fed to the kiln via the feed conveyor; bulk solids will be fed to the kiln feed chute through dual slide gates by an automated feed crane with an "orange-peel" grapple. Some high- and low-Btu liquid waste will be burned directly from a tank truck rather than from a storage tank. Maximum operational feedrates for each waste feed mechanism are included in Table D-7-2a.

Because of the wide variation in the heating value of the wastes to be fed to the kiln, it is of extreme importance to feed the wastes in a manner which achieves a reasonably constant gross heat release in the kiln. A constant heat release will preclude temperature and pressure excursions through the system and the resultant momentary high CO content of the flue gas. Sludge will be delivered to a kiln nozzle and high-Btu liquid waste will be delivered to the kiln burner via continuous, metered, proportioned feed systems to supply a constant thermal load. Low-Btu liquid waste will be delivered to a kiln nozzle via a proportioned feed system to supply a constant thermal demand.

The combined combustion of these wastes will provide a fairly uniform heat release, upon which will be superimposed a periodic release from the feeding of bulk solids and containerized waste. The feed conveyor will have provision for varying the cycle time to accommodate the size of the charge found to be necessary as a function of the feedrates and caloric values.

Bulk Solids Feed System

The bulk solids feed system shown in Appendix D-5, Drawings 8813-00-M-017, 8813-00-M-018 and 8813-00-P-007, consists of an enclosed, automated crane system which will transport the bulk solids from the concrete mix/feed tank to the kiln feed chute. Bulk solids will be fed to the kiln feed chute through dual, horizontal slide gates by the crane system.

The bulk solids feedrate will be controlled by calculating the cycle time required to yield the desired waste feedrate, and setting this cycle time with the control system. The desired feedrate will

Table D-7-2a

Maximum Feedrates of Each Waste Type To the Incinerator at Minimum and Maximum Heating Value of Waste Feed Types

WASTE TYPE	FEED MECHANISM	MAXIMUM[1] FEEDRATE, lb/hr	WASTE STREAM HEATING VALUE, Btu/lb	HEAT RELEASE, MM Btu/hr
High-Btu Liquid	Kiln Burner	3,750 1,500	8,000 20,000	30 30
Sludge	Kiln Nozzle (each of 4)	8,300 3,500	0 20,000	0 70
Low-Btu Liquid	Kiln Nozzle (each of 4)	3,000 3,000	0 8,000	0 24
Containerized Waste	Kiln Containerized Waste Feed System	25,000 5,833	0 12,000	0 70
Bulk Solids	Kiln Feed Chute	25,000 5,833	0 12,000	0 70
High-Btu Liquid	SCC Burners (each of 3)	1,625 650	8,000 20,000	13 13
Low-Btu Liquid	SCC Nozzle	5,000 1,000	0 8,000	0 8

[1] This represents the maximum operational feedrate for each stream. The mechanical design limits for each feed stream are presented in Table 1.7.1-5 of the Trial Burn Plan.

be determined and set by the operator based upon the inventory of wastes to be processed, in compliance with operating limitations.

Containerized Waste Feed System

Fiber, plastic and steel drums of up to 85 gallons in size that do not contain free liquids will be fed directly to the incinerator via the containerized waste feed conveyor and kiln feed chute.

A waste feed schedule will decide the rate and order at which containers will be charged to the kiln. Containers will be grouped according to waste type, carefully moved from the drum storage zones and staged on a motorized conveyor for automatic charging into the kiln. Each drum will be automatically weighed on the conveyor before entering the kiln. The containers will be fed into the kiln by a horizontal section of conveyor which will be isolated from the outside and the kiln proper by a vertical slide gate and a pivot gate.

The containerized waste feedrate will be controlled by calculating the time required to yield the desired waste feedrate, and setting this cycle time with the control system. The cycle time will be such that the charge door will be open for no more than a half minute per cycle.

The capacity of the containerized waste feed system will be 85 gallons. This means only that the system is of sufficient size to physically accommodate containers as large as 85 gallons. The drum feeder will also be capable of operating from 0-45 cycles/hr. This means only that up to one container could be charged to the rotary kiln every 80 seconds; this does not imply that the rotary kiln can or will accept one 85-gallon container every 80 seconds. The physical capacity (i.e., size) of the drum feeder is not directly related to the feedrate of containers to the rotary kiln. The maximum feedrate of containers to the kiln is not determined by the weight or volume of the containerized waste material, but rather by its heating value (total Btu content) and volatility, and what other wastes (e.g., bulk solid, sludge and liquid wastes) are being fed to the kiln and SCC. For example, the kiln could accept containers of low-Btu-content contaminated soil at a higher rate than containers of high-Btu-content organic solids.

The desired feedrate will be determined and set by the operator based upon the inventory and characteristics of wastes to be processed, in compliance with operating limitations (e.g., maximum heat release rate of 75 MM Btu/hr, maximum chlorine and metals feedrates, etc.) and in order to maintain stable incinerator operating conditions.

If required on rare occasions, containers can be moved from the truck unloading area directly to the container feed area for immediate incineration, after previous sampling of the incoming waste and use of the generator-supplied detailed waste characterization, or the identification of a non-hazardous waste material. In this manner, full inventory control procedures will be maintained and completed prior to incineration.

Empty pallets will be stacked in an appointed area of the container staging area. Pallets will be of a construction suitable to support the anticipated maximum container weight. Pallets will be re-used if it is determined that they are uncontaminated by hazardous wastes and still maintain their structural integrity. Used pallets which are determined to be unacceptable for re-use in the staging area will be shredded for incineration.

Steel drums of up to 85-gallon size which contain free liquid will be processed in a covered drum handling area which will provide for the following:

- Drum deheading or punching
- Drum and pallet shredding
- Pumping of contents to a drummed pumpable waste receiver

The waste receiver will be a 2,000-gallon carbon-steel tank with a pump for transferring liquid to a receiving/holding tank.

The drums fed to the kiln will usually be fiber or plastic (steel drums may be fed occasionally) and will contain essentially no free volatile liquid. All steel drums will be deheaded or punched prior to feeding.

Pumpable Waste Feed System

High-Btu liquid will be delivered to the kiln and SCC via recirculation loops with local pressure controllers to maintain constant feed pressure. The amount of the high-Btu liquid fed to the combustion chamber will be regulated by flow controllers which will be set by the combustion temperature controller to automatically maintain the correct operating temperature.

Low-Btu liquid will likewise be delivered to the kiln and SCC via recirculation loops with local pressure controllers to maintain constant feed pressure. The liquid waste fed to the kiln and SCC will be regulated by flow controllers. The desired flow rates will be determined and set by the operator based upon the inventory of wastes to be processed, in compliance with operating limitations.

Sludge will be delivered directly to the one of the kiln nozzles by a piston pump. The sludge fed to the kiln will be regulated by a flow controller. The desired flow rates will be determined and set by the operator based upon the amount of sludge to be processed, in compliance with operating limitations. Most incinerator pumpable feed systems will employ parallel, redundant pumps and recirculation systems with back-pressure control. The sludge feed system, however, will use a variable-stroke, hydraulic-drive piston pump without recirculation.

High-Btu liquid viscosity to the kiln and SCC burners will be controlled by blending to less than 150 SSU (Saybolt Universal Seconds).

<u>Waste Feed and Auxiliary Fuel Feed Cutoffs</u>

The incinerator will be equipped with a number of interlock/control systems which will respond to abnormal operating conditions by automatically activating certain control functions and alarms to tell the operator to take the necessary response actions. The primary purpose of these interlocks is not to shut down the incinerator, but instead to immediately effect those responses necessary to return the incinerator to normal operating conditions as rapidly as possible and/or to interrupt the waste feeds until the proper operating conditions are reestablished. The interlocks are numbered in order of descending importance; i.e., interlock I-1 is the most critical. The locations of all these interlocks are shown in Appendix D-5, Drawings 8813-00-F-064 through 8813-00-F-070.

- Emergency Interlock and Shutdown (I-1).* In order to ensure an efficient, orderly transition to a safe condition during a process upset or mechanical equipment malfunction which might cause major equipment damage, the facility will be operated with an automatic emergency interlock and shutdown sequence.

There are four main process events which will initiate the emergency interlock/shutdown sequence. The events are as follows:

- Primary ID fan failure (both motor auxiliary contacts open or low fan differential pressure (<2"wc))
- High SDA outlet temperature (greater than 500°F for 15 seconds)
- Rotary atomizer failure (motor auxiliary contacts open)
- Loss of electric power/control power

Upon the occurrence of any one of the above events, the following shutdown sequence will automatically commence:

- All waste feed and kiln auxiliary fuel block valves will be closed. Containerized waste feed will be stopped by disabling the feed conveyor. Bulk solids feed will be stopped by disabling the crane feed system.
- Kiln combustion air fan motor interlock will be opened, shutting down the fan.
- The SCC burner on auxiliary fuel will maintain SCC outlet temperature above 1800°F on reduced firing.
- Ambient air will be bled into the SDA through an inlet damper to lower the gas temperature and thus protect the APCE and allow the fabric filter to remain in service.

In the case of a loss of power, an emergency generator will start automatically to supply critical operations such as instruments and controls, the kiln drive, the ash conveyor, the SCC combustion air fan and the two ID fans. The minimum 1800°F temperature (at approximately 25%

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* Refers to interlock numbers on P&IDs (see Appendix D-5)

excess air) will be maintained in the SCC throughout the shutdown period until all residue is discharged from the kiln. This will serve to complete the destruction of the organic constituents in the combustion gases before they exit the SCC. After quenching with ambient air, the reduced-volume combustion gas will flow through the APCE to ensure that stack emissions will not exceed those during normal operations.

Emissions from emergency shutdown events will be no greater than emissions during routine operation of the incinerator. Only in the very unlikely event that both normal operation and the emergency shutdown system fail simultaneously will a bypass around the fabric filter open to protect the bags from high temperatures. The emergency bypass damper will open if the SDA outlet temperature reaches 525°F.

- Waste and Auxiliary Fuel Feed Cutoff (I-2). In addition to the conditions set out above, which cut off all waste feed and the kiln auxiliary fuel, the following item will send an alarm signal to the computer and automatically cut off all auxiliary fuel and waste feed:
  - High SCC outlet temperature (greater than 2400°F for 15 seconds)
- Waste Feed Cutoff (I-3). Besides the conditions mentioned above, the following events will cut off all waste feed (I-3):
  - High CO concentration, averaged over a 60-minute period, in flue gas (greater than 100 ppm on a dry-volume basis, corrected to 7% O_2)
  - High HCl concentration, averaged over a 60-minute period, in flue gas (greater than 100 ppm on a dry-volume basis, corrected to 7% O_2)
  - Low O_2 concentration in flue gas (less than 3% on a dry-volume basis for one minute)
  - High combustion gas flow (greater than 81,000 acfm at 390°F for 15 seconds)
  - Low fabric filter pressure drop (less than 1" wc)
  - High kiln or SCC pressure (greater than -0.05" wc for 30 seconds
  - Low SCC outlet temperature (less than 1800°F)

- Failure of all SCC burners on auxiliary fuel (contact closure at flame safety boards)
- I-1 or I-2 interlocks

These particular I-3 waste feed cutoffs will be tested monthly. The waste feed cutoff system will be tested weekly. In each case, the individual waste stream field-device actions will be noted to ensure waste feed cutoff occurs.

The 60-minute rolling average for CO will be automatically and continuously calculated by the control system. Waste feed will be automatically disabled once this limit is exceeded, and will not be re-enabled until the instantaneous CO is less than 100 ppm. At this time, the rolling average will be zeroed, and a new calculation period will commence. "Guidance on PIC Controls for Hazardous Waste Incinerators," April 1989, allows hazardous waste feed resumption when instantaneous CO levels are less than 100 ppm. No time delay is required.

The one-hour rolling average is calculated only when hazardous waste is fed to the incinerator. After a waste feed cutoff has occurred, the one-hour rolling average is reset. With the resumption of hazardous waste feeds, a new one-hour rolling average is established.

- Kiln Waste Feed and Auxiliary Fuel Feed Cutoff (I-4). In addition to the conditions set out above for I-1 and I-2 interlocks, the following events will cut off only auxiliary fuel and waste feed to the kiln (I-4):
  - Kiln rotation failure (less than 0.1 rpm for 15 seconds)
  - High kiln outlet temperature (greater than 2400°F for 15 seconds)
  - Primary burner failure
  - I-1 or I-2 interlocks
- Kiln Waste Feed Cutoff (I-5). The following event will cut off only waste feed to the kiln:
  - Low kiln outlet temperature (less than 1400°F averaged over a 60-minute period or 1300°F instantaneously)
  - Ash conveyor failure (shuts off solids feed only)
  - I-1, I-2, I-3 or I-4 interlocks

Individual waste streams would be cut off if the respective one-hour rolling average feedrates were greater than those listed below:

- Bulk solids/containerized waste: 25,000 lb/hr
- Sludge: 8,300 lb/hr
- Low-Btu liquid: 5,500 lb/hr
- High-Btu liquid: 8,000 lb/hr

If the above operating limits are exceeded due to equipment malfunction or some other reason, waste feed will be quickly and automatically cut off to control incinerator emissions. Prior to this point, audible and visible alarms will notify the operator to take corrective action.

In all the above cases, the limits which cause incinerator waste feed to stop will cause immediate closure of spring-loaded, fail-closed, automatic block valves on each pumpable feed stream. Containerized waste feed will be stopped by disabling the feed conveyor. Bulk solids feed will be stopped by disabling the crane feed system.

In the cases where only waste feed is shut off (I-3 or I-5 cutoffs), auxiliary fuel will be used to automatically maintain the temperature of the combustion chambers until waste feed can resume. An exception to this would occur if the kiln burner was firing high-Btu liquid when a waste feed cutoff occurred; the burner would have to be relit on fuel oil. In all cases except for the I-2 cutoff, auxiliary fuel will be used to automatically maintain the SCC temperature until normal operations are restored.

The incinerator system design allows for continuous operation of the SCC at a temperature of 1800°F during shutdown modes I-1, I-3, I-4 and I-5, and continuous operation of the SDA and fabric filter during modes I-1 (except for rotary atomizer failure) through I-5.

In I-1 shutdown mode, ambient air will be introduced to the SDA through an inlet damper to cool the combustion gas prior to entry into the fabric filter. The cooled combustion gas will flow through the SDA and fabric filter as during normal incinerator operation; therefore, emissions during the shutdown event will not exceed emissions during normal operation of the incinerator.

In the unlikely event that both the incinerator system and the emergency shutdown system fail simultaneously (e.g., ambient air cannot cool the SDA) during shutdown mode I-1, the fabric filter bypass will be used to protect the filter bags from the high temperature combustion gas during the shutdown event. The SCC will operate continuously during the shutdown event. All waste feeds to the incinerator will have been blocked, and the combustion gas flow rate will have been significantly reduced from normal operating levels before the bypass is used. It is estimated that the fabric filter bypass mode may need to be used once per year. The total duration of emergency shutdown events under condition I-1 will be less than 30 minutes.

Shutdown mode I-2 will be activated upon high SCC outlet temperature conditions (>2400°F). It will not be possible to maintain operation of the SCC during cutoff mode I-2. Shutdown mode I-2 is included in the incinerator design to prevent damage to the SCC in the event of system failure and to guard against possible equipment fires that could result, although such system failures are not expected to occur. Shutdown mode I-2 is therefore designed to block all waste and fuel feeds to the SCC and kiln.

The ambient air inlet damper, SDA and fabric filter will be operated continuously during shutdown event I-2, allowing a reduced flow of combustion gases to be vented through the APCE throughout the duration of the shutdown event. PIC emissions will be controlled by stopping waste feed and by the resident heat in the kiln and SCC. PIC emissions will not increase significantly during the shutdown event. The total duration of the shutdown event under condition I-2 will be less than 30 minutes.

<u>Individual Burner/Nozzle Interlocks</u>

Series-wired safety system interlocks which will disable individual burners are as follows:

- SCC burner X-06
    - ID fan differential pressure less than 2" wc

- SCC combustion air pressure less than 1" wc
- Fuel oil pressure and high-btu liquid waste pressure to burner X-06 less than 10 psi
- Atomizing media pressure to burner X-06 less than 20 psi
- SCC outlet temperature greater than 2400°F
- Burner X-06 flame failure
- DCS (Distributive Control System) permissive loss
  - = I-2 interlock (shuts off fuel oil or waste)
  - = I-1 or I-3 interlock (shuts off waste only)
  - = Total high-Btu liquid flow greater than 8,000 lb/hr (one-hour rolling average; shuts off waste only)

- SCC burner X-07
  - ID fan differential pressure less than 2" wc
  - SCC combustion air pressure less than 1" wc
  - Fuel oil pressure and high-btu liquid waste pressure to burner X-07 less than 10 psi
  - Atomizing media pressure to X-07 less than 20 psi
  - SCC outlet temperature greater than 2400°F
  - Burner X-07 flame failure
  - DCS (Distributive Control System) permissive loss
    - = I-2 interlock (shuts off fuel oil or waste)
    - = I-1 or I-3 interlock (shuts off waste only)
    - = Total high-Btu liquid flow greater than 8,000 lb/hr (one-hour rolling average; shuts off waste only)
- SCC burner X-08
  - ID fan differential pressure less than 2" wc
  - SCC combustion air pressure less than 1" wc
  - Fuel oil pressure and high-btu liquid waste pressure to burner X-08 less than 10 psi

- Atomizing media pressure to X-08 less than 20 psi
- SCC outlet temperature greater than 2400°F
- Burner X-08 flame failure
- DCS (Distributive Control System) permissive loss
  - I-2 interlock (shuts off fuel oil or waste)
  - I-1 or I-3 interlock (shuts off waste only)
  - Total high-Btu liquid flow greater than 8,000 lb/hr (one-hour rolling average; shuts off waste only)

- Kiln burner X-01
  - ID fan differential pressure less than 2" wc
  - Kiln combustion air pressure less than 1" wc
  - Fuel oil pressure and high-btu liquid waste pressure to burner X-01 less than 10 psi
  - Atomizing air pressure to burner X-01 less than 20 psi
  - Kiln outlet temperature greater than 2200°F
  - Burner X-01 flame failure
  - DCS (Distributive Control System) permissive loss
    - I-1, I-2 or I-4 interlock (shuts off fuel oil or waste)
    - I-3 or I-5 interlocks (shuts off waste only)
    - Total high-Btu liquid waste flow greater than 8,000 lb/hr (one-hour rolling average; shuts off waste only)

Interlocks which will disable the kiln nozzles (X-02, 03, 04 and 05) are as follows:

- Atomizing media pressure to waste nozzle less than 5 psi
- Low-Btu liquid waste flow greater than 5,500 lb/hr (one-hour rolling average)
- Sludge waste flow greater than 8,300 lb/hr (one-hour rolling average)
- I-1, I-2, I-3, I-4 or I-5 interlocks

Interlocks which will disable the SCC nozzle (X-09) are as follows:

- Atomizing media pressure to waste nozzle less than 5 psi
- Low-Btu liquid waste flow greater than 5,500 lb/hr (one-hour rolling average)
- I-1, I-2 or I-3 interlocks

D.7.2.8 Stack Gas Monitoring

Combustion gases will be analyzed for CO, HCl, THC, O_2 and opacity by a continuous emissions monitoring (CEM) system. CO, HCl and O_2 will be monitored with redundant analyzers since these parameters are associated with waste feed cutoff.

The CO, HCl, THC and O_2 analyzers will have an extractive sampling system with the sampling point mounted in the stack. CO will be monitored with redundant non-dispersive infrared (NDIR) analyzers; O_2 will be monitored with redundant paramagnetic analyzers; HCl will be monitored with redundant specific-ion or NDIR gas filter correlation analyzers; THC will be monitored with an FID or NDIR analyzer. The opacity will be monitored with a visible-light transmissometer located at grade, sighting across the ductwork between the ID fans and the stack.

The analyzer outputs will be transmitted to the control room to report to indicators, recorders, alarms and interlocks. All of these analyzers will be self-calibrating; however, they will still be manually calibrated on a periodic basis per the manufacturer's recommendations. A more detailed description is given in the manufacturer's literature included in Appendices D-4-4, D-4-5 and D-4-6.

D.7.2.9 Air Pollution Control Equipment (APCE)

General

Standard APCE operating conditions are listed in Table D-7-2. The APCE will remove at least 99% of the HCl and 90% of the SO_2 from the combustion gases and limit particulate emissions to no greater than 0.02 gr/dscf.

Spray dryer absorber/fabric filter (SDA/FF) systems are highly efficient in removing fine particulate and particulate metal emissions from the incinerator combustion gas stream. The metals removal efficiency is designed to be greater than

- 99% for barium, silver, chromium and beryllium
- 98% for lead, cadmium, arsenic, thallium and antimony
- 90% for mercury

The APCE is expected to exceed these minimum efficiencies. The metals removal efficiency of the APCE is further discussed in Section L and in the Trial Burn Plan in Appendix D-6.

Table D-7-2
APCE Operating Conditions

Control Equipment	**Normal Operating Conditions**
SDA	
Lime slurry flow rate	5 - 130 gpm
Lime slurry concentration	2 - 20%
Lime/HCl stoichiometric ratio	1.5 - 3:1
Inlet combustion gas temperature	1800°F - 2200°F
Outlet combustion gas temperature	350°F - 450°F
Pressure differential	3 - 5" wc
Fabric filter	
Pressure differential	2 - 8" wc
Air-to-cloth ratio (with one compartment off line for cleaning)	4:1

SDA

The SDA will be a vertical cylindrical unit approximately 36'-9" in OD by 82' high, with a 60° conical bottom designed to

- Further cool the combustion gases from a range of 1800°F-2200°F to a range of 350°F-450°F
- Neutralize and remove acid gas from the combustion gases
- Remove a portion of the particulate from these gases
- Remove most of the metals from these gases

Combustion gases will enter the bottom of this unit, flow up through a central refractory-lined duct, and be dispersed symmetrically from this duct into the absorber chamber at a velocity and direction that will ensure optimal contact with the cloud of atomized lime slurry droplets introduced into the chamber by a rotary atomizer. The gases will then flow down through the chamber and exit through a bottom side duct. As the gases contact and pass through the cloud of atomized lime slurry, the water content of the slurry will cool the gases while being vaporized. Simultaneously, the lime in the slurry will react with the HCl and SO_2 in the gases to produce calcium salts. Some of the resulting dry material, consisting of calcium salts, fly ash and excess lime, will fall to the conical bottom of the unit. This dry material will be discharged through double valves onto a conveyor system which will carry it to a recycle silo or to a storage silo from where it will discharge to the lime system for recycle or to a lugger box for transport to off-site disposal.

The SDA will be fabricated of carbon steel. The unit will be designed to remove approximately 1,300 lb/hr of HCl from the combustion gases and to maintain at least 30 seconds of gas retention time at maximum gas flow.

Filtrate from the inorganic waste treatment system or fresh process water will be used as makeup water in the SDA. The composition of the filtrate used will not exceed the standards listed in Table D-8-2 in Section D.8.4. The total feedrate of solid materials to the SDA, including fresh lime slurry, recycled lime slurry and dried solids, and inorganic waste treatment system filtrate, will be approximately 12,000 lb/hr, of which 2,000 lb/hr will be contained in the filtrate feed. The increased loading of solid material will not affect the total particulate emissions from the incinerator stack. The increased emissions of organic compounds, metals and other compounds through the incinerator stack resulting from the use of filtrate in the SDA represent only a small percentage of the total emissions from the incinerator stack. Use of inorganic filtrate in the SDA is further discussed in Section L of this application.

Thermostatically controlled electric heaters and insulation will be provided for all hoppers, valves and conveyors which are part of the dried solids system in order to ensure that the hygroscopic $CaCl_2$ remains free flowing.

Fabric Filter

The fabric filter (baghouse) will consist of four compartments through which the combustion gases will pass to remove particulates. The units will provide an air-to-cloth ratio of approximately 4:1 with one compartment off line for cleaning. The elements will be periodically cleaned with back-flowing compressed air. The removed particulate will fall to the bottom hoppers of each unit from which it will be discharged into a conveyor. The conveyor will move this material to the recycle silo for recycle in the lime system or to the storage silo for discharge to a lugger box for transport to off-site disposal.

Each baghouse compartment will have a clean air plenum and housing section which will contain approximately 210 bags. Each bag will be approximately 6" in OD by 20' long. The baghouse will be fabricated from 3/16" mild steel plate, of gas-tight, welded construction, and stiffened to withstand the maximum operating negative pressure. The compartment tube sheet will support the bags and will provide for top bag/cage removal.

The baghouse will be equipped with a high-efficiency pulse-jet cleaning system. The cleaning system will use low-pressure compressed dry air to dislodge the accumulated particulates from the bags.

The pressure differential set point which initiates the cleaning cycle will be adjustable, but normally will be about 6" wc. The bags will be designed for a 30" wc vacuum, which is greater than the maximum negative pressure of the ID fan. The design allows the bags to be cleaned either with the entire baghouse in operation or with an individual compartment of the baghouse closed off (on-line or off-line cleaning). For the four-compartment filter, one-fourth of the total bags can be isolated for cleaning or maintenance at a time. The remaining three-fourths of the filter capacity will be more than adequate to accommodate the process requirements.

The filter media will be equivalent to 16 oz/yd^2 woven fiberglass with a Teflon finish or a Gortex membrane. Bags will include snap rings for easy and dust-tight installation. The bags will be held in place by bag cages constructed of galvanized steel wire.

Preventive maintenance procedures for the fabric filter will be provided by the equipment vendor prior to operation. See the fabric filter inspection schedule in Section F. Broken bags will be detected by an alarm from the stack opacity analyzer and by a low differential pressure alarm.

The fabric filter will be provided with an emergency bypass duct for protection against high combustion gas temperatures. The emergency interlock and shutdown system will protect the bags from exposure to temperatures above 500°F. The SDA will be equipped with an ambient-air inlet damper so that hot combustion gases from the SCC can be cooled prior to being vented to the fabric filter and stack. If, however, the shutdown system does not operate properly and the gas temperature reaches 525°F, the emergency bypass damper solenoid will be de-energized, opening the bypass.

Thermostatically controlled electric heaters and insulation will be provided for all hoppers, valves and conveyors which are part of the dried solids system in order to ensure that the hygroscopic $CaCl_2$ remains free flowing.

ID Fan and Stack

The total capacity of the two parallel ID fans will be approximately 90,000 acfm at 390°F and

25" wc differential. Each fan will provide 50% of the total capacity, will have radial-tip blades and will be of carbon-steel construction. Each fan will be driven by a 300-hp motor. An inlet-volume-control damper will be provided in the common inlet duct. The fans will be sized to maintain a negative pressure throughout the system to prevent fugitive emissions. See Appendix D-4-8 for the manufacturer's capacity information.

The incinerator will be equipped with a steel stack approximately 5'-6" in ID and 200' high with a maximum design exit velocity of approximately 3,600 ft/min. The free-standing stack will have standard sampling ports and an access platform for stack testing per FDER regulations. Stack testing requirements are discussed further in Appendix D-6, the incinerator Trial Burn Plan.

Dried Solids Storage and Handling System

Dried solids from the SDA and fabric filter will be collected and conveyed to the dried solids storage silo (T-01) and recycle silo (T-02) by enclosed drag conveyors. Each fabric filter compartment will be isolated from the conveyors by a motor-driven, double-flap discharge valve. The dried solids system will consist of a storage silo, a recycle silo and a recycle suspension tank, with auxiliary equipment such as bucket conveyors and a pug mill.

The dried solids storage silo (T-01) will have a capacity of 5,000 ft^3. It will be made of carbon steel with dimensions of 16' diameter with a 55° conical bottom and an overall tank height of 31'.

The recycle silo (T-02) will have a capacity of 1,350 ft^3. It will be made of carbon steel with approximate dimensions of 12' diameter with a 55° conical bottom and an overall tank height of 16"-4'.

The recycle suspension tank (T-04) serves the purpose of mixing the recycled alkaline reagent prior to introduction to the SDA. T-04 will have a capacity of 3,000 gallons. It will be made of fiberglass-reinforced plastic (FRP) with approximate dimensions of 8' diameter with a dished bottom and a height of 8' tangent-to-tangent.

The recycle silo will be equipped with a dehumidified-air-fluidizing system to maintain flow of the dried solids. A variable-speed-drive rotary valve will control discharge of the recycled dried solids which will be conveyed to the recycle suspension tank to provide about a 40% total-solids slurry as feed to the SDA atomizer from the slurry feed tank. Dried solids not needed in the lime slurry will be discharged from the dried solids storage silo through a pug mill for dust control prior to disposal in a lugger box.

Thermostatically controlled electric heaters and insulation will be provided for all hoppers, valves and conveyors which are part of the dried solids system in order to ensure that the hygroscopic $CaCl_2$ remains free flowing.

The recycle silo receives dried solids from the SDA and fabric filter that are recycled to improve absorption and lime utilization. The recycle suspension tank serves the purpose of reslurrying the dried solids with water. The resulting mix is then pumped at a constant rate to the SDA head tank where make-up lime is added at a rate determined by the measured HCl emission at the stack. The head tank then feeds the atomizer by gravity at a constant head and at a rate determined by the SDA temperature control system. The overflow (balance) from the head tank is returned to the recycle suspension tank.

The dried solid storage silo also receives dried solids from the SDA and fabric filter. The solids are storaged in the silo until they can be wetted in the pug mill and discharged to lugger boxes.

The general arrangement of the silos, tanks, conveyors and pug mill, as well as the design of the secondary containment system for these units, are shown in Appendix D-5, Drawing 8813-00-M-026. The foundation design details are provided in Appendix D-5, Drawing 8813-00-S-011. Secondary containment calculations for the recycle suspension tank are included in Appendix D-2 (sheet 10 of 11).

<u>Lime System</u>

A "packaged" plant for producing lime slurry from pebble lime will provide lime slurry for the

APCE. The pebble lime storage silo will be of a nominal 175-ton capacity and will include a caged ladder and roof handrail, hinged rooftop manway, bin vent dust collector, pneumatic filling line with quick-connect coupling for tanker-truck hookup at grade, four level switches, activated bin bottom and manual knife-gate isolation valve on the bin bottom discharge.

Pebble lime will be pneumatically conveyed by the blower mounted on the bulk truck to the silo. The 12'-diameter silo will be approximately 41' high. The bin vent will be 8' higher than the silo roof.

The slurry system will include the following:

- Two parallel slaking systems
- Variable-speed volumetric feeders with remote speed-control electronics to be mounted in the control room
- Agitated slurry mix tank and feed tank
- Level controls
- Makeup water control valves
- Centrifugal slurry pumps
- Free-standing control panel
- Ultrasonic slurry density transmitter mounted in slurry mix tank

D.7.2.10 Nozzle and Burner Design

__Kiln Nozzles/Burners__

The kiln feed hood (faceplate) will contain ports for one burner and four waste nozzles, a feed chute with dual slide gates for bulk and containerized solids, and two turbulence air nozzles. The approximate arrangement of this equipment is shown in Appendix D-5, Drawing 8813-00-M-021.

The kiln will be equipped with one 30 MM-Btu/hr dual-fuel burner capable of burning auxiliary fuel or high-Btu waste. The burner will be a North American burner Model No. 6385-14 (or equivalent) with manual flame-length adjustment. The forced-draft burner will be provided with a complete burner management system including controls, gas pilot, flame supervision, and safety shutoff and interlock devices.

The burner also will be equipped with an external-atomizing fuel gun which will be provided with atomizing media at 60 to 90 psi. The atomizing media for all burners and nozzles will normally be air; however, steam may also be used for atomizing sludges and liquids at times. The atomizing media pressure at the atomizing tip will be regulated by a differential pressure controller to approximately 10 psi above the pressure of the waste. With this type of control, a burner turndown ratio of 4:1 on liquids is possible. A more detailed description of the burner is given in the manufacturer's literature included in Appendix D-4-1. The model numbers of the equipment in this literature is not identical to the model number above, but the equipment is essentially identical.

The faceplate of the kiln will also be equipped with four externally atomized nozzles for low-Btu liquid and sludge. These nozzles will be provided with atomizing media at 60 to 90 psi, and atomizing media pressure at the nozzle will be regulated to about 10 psi above the waste pressure. These nozzles will be Ripco Model LSA 125-4R or Model LSA 300-60R (or equivalent). A more detailed description of the nozzles is given in the manufacturer's literature included in Appendix D-4-2. The model numbers of the equipment in this literature are not identical to the model number above, but the equipment is essentially identical.

The low-Btu liquid and sludge nozzles will be designed for flow rates of up to 10 gpm. These nozzles can be turned down by a ratio of 10:1. The four nozzles can be arranged for feeding any combination of the various pumpable waste streams.

SCC Nozzles/Burners

The SCC will contain ports for three tangentially mounted burners, one waste nozzle and one turbulence air nozzle. The arrangement of this equipment is shown in Appendix D-5, Drawings 8816-00-A-022 and 8816-00-A-023. The SCC burners will be three 13-MM Btu/hr T-Thermal Model LV-13 (or equivalent) high-intensity burners, each of which will be set up to burn auxiliary fuel or high-Btu waste. These forced-draft burners will be supplied with atomizing media at 60 to 90 psi. The pressure of the atomizing media at the nozzle will be controlled at 10 psi above the waste pressure by a differential pressure controller.

With this type of control, a turndown of 4:1 on liquids can be obtained. As with the kiln burner, these burners will be provided with complete burner management systems.

Although all three burners can fire waste, at least one of the burners will always fire fuel oil. The function of the fuel oil burner is to minimize the need for purging the SCC and the attendant thermal shock to the refractories for each interruption in waste feed to the burners. A more detailed description of these burners is given in the manufacturer's literature included in Appendix D-4-3. The model number of the equipment in this literature is not identical to the model number above, but the equipment is essentially identical.

The burners will be provided with a burner management system to control burner light-off, operation and shutoff. The system will be designed to control the system air purge cycle prior to burner ignition; control the lighting of the burners; and monitor the flame, combustion air pressure, fuel pressure and atomizing media pressure. The burner management system will be interlocked to immediately close the fuel double-block valves when unsafe system conditions occur.

The SCC will also be equipped with one externally atomized nozzle for low-Btu liquid. This nozzle will be provided with atomizing air at 60 to 90 psi, and atomizing media pressure at the nozzle will be regulated to about 10 psi above the waste pressure. This nozzle will be a Ripco Model LSA 125-4R (or equivalent). A more detailed description of the nozzles is given in the manufacturer's literature included in Appendix D-4-2. The model numbers of the equipment in this literature are not identical to the model number above, but the equipment is essentially the same.

The low-Btu liquid nozzle will be designed for flow rates up to 10 gpm. This nozzle can be turned down by a ratio of 10:1.

<u>Combustion Air System</u>

Combustion air to each burner will be supplied via flow ratio control to maintain the desired amount of excess air to the burner. Lead/lag modules will be employed on the burners to ensure that air leads fuel on increasing firing loads and lags fuel on decreasing loads.

Combustion air will be supplied to the kiln through the primary burner, the turbulence air nozzles and the tertiary air damper. The air for these systems will be supplied by the kiln combustion air fan for the primary burner and turbulence air nozzles, and by the ID fans for the tertiary air damper.

The amount of excess air in the kiln, including tertiary (induced) air introduced via the feed-chute air-inlet-control damper, will vary from 50% to 150% depending upon whether waste is being fed and the properties of the waste composite being incinerated. It will, however, be approximately 100% under most operating conditions.

Combustion air will be mainly supplied to the SCC through the burners by one combustion air fan. In addition, a minor volume of gas from storage tank breathing will be vented to the SCC through the turbulence air nozzle.

The amount of excess air introduced into the SCC burners normally will be 10% to 25%, as only relatively high-Btu, clean-burning waste or auxiliary fuel will be burned in the SCC; however, a large amount of excess air will enter the SCC from the kiln.

D.7.2.11 Construction Materials

The kiln will consist of a welded, carbon-steel shell lined with 12" of Harbison-Walker "Kala Thermax" 50%-alumina firebrick (or equivalent). The transition chamber between the kiln and the SCC will be fabricated of carbon steel and lined with 6" of Harbison-Walker "Kala" 50%-alumina firebrick (or equivalent) backed with 2" of Harbison-Walker "HW-20" insulating brick (or equivalent). The SCC will be a welded, carbon-steel vessel lined with 6" of Harbison-Walker "Ufala" 60%-alumina firebrick (or equivalent) backed by 1" of Harbison-Walker "HW-23" insulating brick (or equivalent). The firebrick maximum service temperature is approximately 3000°F.

The APC system will be fabricated of carbon steel. The fabric filter will be equipped with Teflon-coated fiberglass or Gortex membrane bags.

The waste feed systems will be constructed of carbon steel.

D.7.2.12 Temperature, Pressure, and Flow Indicating and Control Devices

General

The incineration system will be equipped with a state-of-the-art monitoring and control system to facilitate compliance with permit conditions and to collect process information, effect optimum operation, and detect and prevent damage from process-condition excursions to the system.

The incineration system monitoring and control functions will be centralized in the control room and will be distributed between two systems: the analog/digital loop controllers and the color CRT stations. The overall system will be designed to permit direct communications among all components. The control system will be utilized to implement the desired control functions for safe and efficient plant operation.

The control system will handle all analog and digital control, including alarms, emergency interlocks and status reporting. It will also form the basis of the data acquisition system, providing graphic and numerical information concerning the status of the process.

A semi-graphic display panel will include equipment status lights and digital displays of key process variables. The data acquisition system will provide a permanent record of critical parameters. Several closed-circuit TV monitors will enable the operator to view various aspects of the incinerator operation. Two-way radios will enable the operator to communicate with operators and maintenance technicians working on and around the system, and to communicate with personnel in other parts of the facility. A telephone will be also installed in the control room.

Those instruments that are germane to demonstrating compliance with permit conditions are described in this section and are presented in the P&IDs included in Appendix D-5. Detailed information on each sensing device including make, model and range will be supplied later, but before facility construction.

For each of the monitoring instruments described in this subsection, the measuring device itself will be located on or in the system where the measurements are to be taken. The measurements will be transmitted to the control room where they will be reported to an indicator, a recorder, an alarm, an interlock, an indicating controller or a combination of these devices. The indicators will be CRTs; the recorder will be a computer which will record measurements on diskettes, tape or paper; alarms will be audible and visible on the control panel or CRT. The interlocks will initiate the automatic responses, such as waste feed cutoffs, described in later sections. The control system will operate modulating valves or other devices to manage normal operation of the system.

Table D-7-3 is presented to further clarify and summarize the monitoring and control systems for this incineration system.

Table D-7-3
Control Instrument Summary

UNIT	INDICATING	RECORDING	INDICATING & CONTROLLING	ALARM
Waste Pump Status	X			
Waste Tank Level	X			X
Rotary Kiln Outlet Temperature		X	X	X
SCC Outlet Temperature		X	X	X
Pumpable Waste Feedrate		X	X	X
Solid Waste Feedrate	X	X		X
Auxiliary Fuel Feedrate		X	X	X
Rotary Kiln Pressure		X	X	X
Rotary Kiln 1) Main Burner On	X			
2) Main Burner Failure				X
SCC 1) Burners On (3)	X			
2) Burner Failure				X
Atomizing Media Pressure to Burners			X	X
Combustion Air Fans 1) On/Off Status	X			
2) Low Combustion Air Pressure				X
Pumpable Waste Pressure to Burner			Local	X
Auxiliary Fuel Pressure to Burner			Local	X
Combustion Air Flows			X	

Table D-7-3
Control Instrument Summary (Cont.)

UNIT	INDICATING	RECORDING	INDICATING & CONTROLLING	ALARM
Instrument Air Pressure	X			X
Rotary Kiln Speed			X	X
Rotary Kiln Axial Movement				X
Ash Conveyor On/Off Status	X			X
Process Water Pressure	X			X
SCC Pressure	X			
Fabric Filter Pressure Drop	X			X
SDA Outlet Temperature		X	X	X
Lime Slurry Flow		X	X	X
Rotary Atomizer				
1) On/Off Status	X			
2) Malfunction				X
3) Vibration	X			X
4) Amperage				X
ID Fan				
1) On/Off Status	X			
2) Failure (diffential pressure)				X
3) Vibration	X			X
4) Amperage	X			X
Stack O_2	X	X		
1) Low Concentration				X

Table D-7-3

Control Instrument Summary (Cont.)

UNIT	INDICATING	RECORDING	INDICATING & CONTROLLING	ALARM
Stack CO	X	X		
1) High Concentration				X
2) Analyzer Failure				X
Stack HCl	X	X		
1) High Concentration				X
Stack THC	X	X		
1) High Concentration				X
Stack Gas Flow Rate	X	X		X
Stack Gas Opacity	X	X		X

LEGEND

INDICATING Variable will be displayed by the central control system.

RECORDING Variable will be continuously recorded in the control room to provide a historical, permanent record of that variable.

INDICATING & CONTROLLING Variable will be indicated and automatically controlled by the central control system unless otherwise noted.

ALARM A visible and audible alarm will sound in the control room. The alarm trip point will be calculated as a percentage of the range for each process variable.

LOCAL Variable is controlled automatically with local instrumentation rather than by the central control system.

Waste Feed Monitoring/Control

The flow rates of all the liquid waste feeds to the kiln and SCC will be continuously measured by coriolis mass flowmeters (or their equivalent), located in each of the lines between the recycle loops and the burners or nozzles. The output of the monitors will be stored in the computer. A more detailed description of this type of flowmeter is given in the manufacturer's literature included in Appendix D-4-9.

The flow rate of low-Btu liquid and sludge will be maintained by flow controllers operating upon the signal provided by the monitors. These controllers will be set to provide a constant base load of waste to the kiln, the magnitude of which will be set by the operator based on the amount and kind of waste to be processed and its properties. Flow controllers will also regulate the flow rate of the high-Btu liquid to the kiln and SCC burners. The set point of these flow controllers will be reset by the combustion temperature controllers to maintain the preset operating temperatures.

Each charge of containerized waste fed to the kiln will be weighed on a weigh conveyor. Each charge of bulk solids fed to the kiln will be weighed by the feed crane integral weighing device. The computer will time-average the signals and report feedrates in lb/hr on indicators, and store this information in a database. Individual container and feed crane charge weights will also be recorded.

The feedrate of containerized solids fed to the kiln will be controlled by setting the cycle time of the feed conveyor. The cycle time will be determined and set by the operator, based on the inventory of wastes to be processed, in compliance with operating limitations.

The feedrate of bulk solids fed to the kiln will be controlled by setting the cycle time of the feed crane. The cycle time will be determined and set by the operator, based on the inventory of wastes to be processed, in compliance with operating limitations.

Fuel Feed Monitoring/Control

Auxiliary fuel flow rates to the kiln burner and the SCC burners will be continuously measured by positive-displacement or orifice flowmeters. The output of these monitors will be transmitted to the control room where the feedrates will be stored in the computer database. The flow rates of the auxiliary fuel will be regulated by flow controllers. The combustion chamber temperature controller will reset the auxiliary fuel flow controller set point to automatically maintain the prescribed operating temperature.

A selector switch in the control room will allow the operator to select either auxiliary fuel or waste for temperature control if the combustion chamber temperature is above 1400°F in the kiln and/or 1800°F in the SCC. Otherwise, auxiliary fuel only will be used.

Combustion Air Monitoring/Control

Combustion air flow rates to the kiln and SCC burners will be continuously measured with thermal dispersion flowmeters located in the lines to each of the burners and in the common line to the two kiln turbulence air nozzles. These measurements will report to indicating controllers.

Combustion air flow to the burners will be controlled at a variable ratio to burner waste and fuel flow. The set point for the air flow will be a function of the waste/fuel heating values. The controller will modulate individual combustion air dampers to maintain the correct ratio.

Atomizing Media Differential Pressure Monitoring/Control

The burner or nozzle atomizing media differential pressure will be continuously measured with a differential pressure transmitter which will be connected to both the atomizing media and the waste or fuel piping. The controller will use the transmitter output to modulate a pressure control valve on the atomizing media.

Kiln Temperature Monitoring/Control

The kiln outlet temperature will be controlled to ensure adequate burnout of the ash and stable operation of the SCC. This will be accomplished by controlling the feedrates of one of the several wastes or auxiliary fuel to the kiln, using a cascade control system with the kiln temperature controller adjusting the set points of the waste or auxiliary fuel flow controllers. A selector switch in the control room will allow the operator to select one of several waste feeds for temperature control if the kiln temperature is above 1400°F.

The temperature of the combustion gases exiting the kiln will be continuously measured by triple redundant type-R thermocouples located in the transition chamber. The signal from these devices will be sent to the control room to report the temperature to a recorder and an indicating controller. Temperatures which fall outside of the preset limits will be reported to alarms and interlocks.

The thermocouples will be installed in high-alumina ceramic protection tubes and inserted to a depth of at least 36". The approximate thermocouple locations are shown on Drawing 8813-00-F-070 in Appendix D-5.

Kiln Pressure Monitoring/Control

The kiln will be operated at a partial vacuum to ensure that there are no fugitive emissions. The kiln is chosen as the control point because it is the furthest from the ID fan; thus if the kiln is at a partial vacuum, the entire process train will also be at a negative pressure. The pressure control will be accomplished by modulating the ID inlet damper to maintain the set point.

The internal kiln pressure will be continuously measured using a draft-range differential pressure transmitter with the low-pressure side connected to the kiln inlet and the high-pressure side vented to the atmosphere. This device will transmit the measurement to the control room to report to a recorder and an indicating controller. A pressure which falls outside a preset limit will be reported to alarms and interlocks.

SCC Temperature Monitoring/Control

The SCC outlet temperature will be controlled to ensure adequate burnout of residual organics. This will be accomplished by controlling the feedrates of the high-Btu waste and auxiliary fuel to the SCC, using a cascade control system with the SCC temperature controller adjusting the set points of the high-Btu waste or auxiliary fuel flow controllers.

Temperatures of the combustion gas exiting the SCC will be continuously measured by triple redundant type-R thermocouples and transmitters located in the ductwork between the SCC and the SDA. The signal from these devices will be sent to the control room to report to a recorder and an indicating controller. Temperatures which fall outside of preset limits will be reported to alarms and interlocks.

The thermocouples will be installed in high-alumina ceramic protection tubes and inserted to a depth of at least 12". Since the thermocouples are located in the downcomer to the SDA, they will not be subject to burner flame radiation. Approximate thermocouple locations are shown on Drawing 8813-00-M-020, Appendix D-5.

SDA Monitoring/Control

Since the acid gas removal efficiency of the SDA is affected by the outlet temperature and since the fabric filter following the absorber can be damaged by excessive temperatures, the temperature of the gases exiting the SDA will be carefully controlled. These dual functions of acid gas absorption and outlet temperature control will be regulated by two controllers.

SDA outlet temperature control will be accomplished by modulating the total flow rate of the diluted slurry sprayed into the absorber. The slurry flow control set point will be adjusted on cascade control by a temperature controller in the SDA outlet.

Acid gas absorption control will be accomplished by modulating the flow rate of concentrated (10-20%) lime slurry to the head tank above the SDA. The lime slurry flow set point can be set by the operator to maintain a given stoichiometric ratio, or it can be adjusted on cascade control from the HCl concentration controller. The water flow control set point will be adjusted by the dried solids recycle suspension tank level controller.

The SDA will contain a redundant type-J thermocouple assembly installed in the exiting ductwork. The thermocouple will be connected to a temperature recorder and controller which will regulate the amount of slurry added and also serve the alarm and interlock system.

The feedrate of lime slurry to the SDA will be continuously measured with magnetic flowmeter. The measurement will be transmitted to the control room to a recorder and controller.

Fabric Filter Monitoring

The differential pressure across the fabric filter will be continuously measured with a differential pressure transmitter. High and low differential pressure will activate alarms.

Combustion Gas Velocity Indication

The combustion gas flow rate will be continuously monitored by a thermal-dispersion flowmeter mounted in the stack. The measurements will be sent to the control room to a recorder, an indicator, an alarm and interlocks. Drawing 8813-00-M-020 in Appendix D-5 shows the location of the stack sampling ports where the flowmeter is mounted. A more detailed description of this device is given in the manufacturer's literature included in Appendix D-4-10.

P&IDs

Drawings 8813-00-F-048 through 8813-00-F-080 in Appendix D-5 are the P&IDs for the organic treatment facility. They are presented to more fully illustrate the details of the facility monitoring and control systems.

Continuous Emissions Monitoring (CEM)

Combustion gases will be analyzed for CO, HCl, THC, O_2 and opacity by a CEM system. CO, HCl and O_2 will be monitored with redundant analyzers since these parameters are associated with waste feed cutoff.

The CO, HCl, THC and O_2 analyzers will have an extractive sampling system with the sampling point mounted in the stack. CO will be monitored with redundant non-dispersive infrared (NDIR) analyzers; O_2 will be monitored with redundant paramagnetic analyzers; HCl will be monitored with redundant specific-ion or NDIR gas filter correlation analyzers; THC will be monitored with an FID or NDIR analyzer. The opacity will be monitored with a visible-light transmissometer located at grade, sighting across the ductwork between the ID fans and the stack.

The analyzer outputs will be transmitted to the control room to report to indicators, recorders, alarms and interlocks. All of these analyzers will be self-calibrating; however, they will still be manually calibrated on a periodic basis per the manufacturer's recommendations. A more detailed description is given in the manufacturer's literature included in Appendices D-4-4, D-4-5 and D-4-6.

CO and O_2 Analyzer Description

General

Type:	Extractive		
Make:	Horiba		
Model:	ENDA-1000 Series (for CO, O_2)		
Range:	CO:	0 - 200 ppm	} dual range analyzer or
	CO:	0 - 2000 ppm	} two separate analyzers
	O_2:	0 - 25% (dry volume)	
Accuracy:	CO:	Calibration error $\leq$ 5% of full scale	
	O_2:	Calibration error $\leq$ 0.5% O_2 (as defined in CO guidance)	
Response Time:	CO:	$\leq$ 1.5 minutes for 95% of final value	
	O_2:	$\leq$ 1.5 minutes for 95% of final value	

These makes and model numbers are typical only and meant to indicate quality of manufacture. Other equivalent equipment may be substituted during construction.

A dual-range CO analyzer or two separate CO analyzers with automatic range switching will be provided, as required by "Guidance on PIC Controls for Hazardous Waste Incineration," April 1989. Range 1 will be 0-200 ppm, while Range 2 will be 0-2,000 ppm.

Method to Correct CO to 7% O_2 (Dry Basis). CO will be corrected to 7% O_2 on a dry basis as follows:

Both the CO and the O_2 signals will be transmitted to the plant control system as continuous 4-20 ma signals. The CO and O_2 analyzers will be located in the same unit and the measurements based on the same gas sample; consequently, they will reflect simultaneous conditions. If two separate CO analyzers with automatic range switching are provided, the control system will, for each program execution cycle (approximately one second), select one of the two CO signals. The low range will normally be used, and the high range will only be used when the CO concentration is above 95% of the low range. The selected CO signal will be corrected to 7% O_2 by using the O_2 signal in the following equation:

$$CO_c = CO_m \times \frac{14}{21 - O_2}$$

where	CO_c	= CO corrected [ppm]
	CO_m	= CO measured [ppm]
	O_2	= O_2 measured [%]

The sample will be dried (cooled to 2°C - 3°C) before entering the analyzers, and all measurements will consequently be on a dry basis.

The corrected CO concentration value will be sampled every 15 seconds and averaged over a one-minute period. The one-minute averages will be logged (recorded) by the process control system.

Rolling Average Calculation. The hourly rolling average will be calculated in the plant control system using the 15-second sample values. The rolling average calculation will be performed as follows:

- Each minute, the four most recent 15-second values will be averaged by adding the four numbers and dividing the result by four. This one-minute average will be used to update the one-hour rolling average.
- The one-hour rolling average will only be calculated when waste is fed to the incinerator. When waste feed to the incinerator is cut off, the one-hour rolling average will be reset. When waste feed is started, the one-hour rolling average calculation will be resumed.

The following formula will be used:

$$CO_{ra}(T) - \frac{1}{T}\sum_{i-1}^{T} CO_c(i) \qquad 1 \le T \le 60$$

CO_{ra} (T)	=	One-hour rolling average for minute (T)
(T)	=	Number of minutes since waste feed started
CO_c (i)	=	One-minute average for minute (i)

When waste has been fed for one hour or more, the rolling average becomes a true one-hour rolling average based on the 60 most recent one-minute averages:

$$CO_{ra}(T) - \frac{1}{60}\sum_{i-T-59}^{i-T} CO_c(i) \qquad T \ge 60$$

Sampling System. The system will be equipped with one common sample extraction and sample conditioning system for the O_2 and CO analyzers. The sample will be dried (cooled to 2°C to 3°C for condensation and removal of moisture) before entering the analyzers. Thus, measurements will all be done on a dry-volume basis.

Routine Calibration. The analyzer system will be calibrated daily by performing a true zero and span calibration for all analyzers. The procedure will be initiated manually or automatically. Furthermore, the complete system, including the components in the sampling system, will be inspected daily to ensure proper operation. The calibration will be performed by using ambient air as zero gas for CO and span gas for O_2, and using 180-ppm span gas for the low range CO analyzer and 1,800 ppm for the high range CO analyzer.

One of the CO span gases will be used as zero gas for O_2. These calibration gases will be mixtures of N_2 and CO with a tolerance of 1% certified by the manufacturer. Calibration gases will be introduced at the sample probe (at the stack end of the sampling line) to check total system integrity.

Calibration gas concentrations described are meant to convey approximate ranges only. Actual concentrations used may differ slightly from those mentioned.

Quarterly Calibration Error Test. Every three months, a calibration error test, as defined by "Guidance on PIC Controls For Hazardous Waste Incineration," April 1989, will be performed. The test will cover all analyzers.

1. **Procedure**. The procedure for testing calibration error is to set the instrument zero and span with the appropriate standards, and then to repeatedly measure a standard in the middle of the range. In order to minimize bias from previous analyses, the sequence of standard introduction will alternate between high and low standards prior to the mid-level standard (e.g., high, mid, low, mid, high, mid, low, mid, etc.) until six analyses of the mid-level standard are obtained, with three values obtained from upscale approach and three values obtained from downscale approach.

The differences between the measured instrument output and the expected output of the reference standards are used as the data points.

2. **Calculations**. For each of the six measurements made, the arithmetic difference between the midpoint reference value and the measured value will be calculated. Then the mean of the difference, standard deviation, confidence coefficient, and calibration error will be calculated using the following equations.

3. **Arithmetic Mean**. The arithmetic mean of the differences, $\bar{d}$, will be calculated as follows:

$$\bar{d} = \frac{1}{n} \sum_{i=1}^{n} d_i$$

Where n = number of data points

$\sum_{i=1}^{n} d_i$ = algebraic sum of the individual differences d_i

4. <u>Standard Deviation</u>. The standard deviation S_d, will be calculated as follows:

$$S_d = \sqrt{\frac{\sum_{i=1}^{n} d_i^2 - \frac{(\sum_{i=1}^{n} d_i)^2}{n}}{n-1}}$$

5. <u>Confidence Coefficient</u>. The 2.5% error confidence coefficient (one-tailed), CC, will be calculated as follows:

$$CC = t_{0.975} \frac{S_d}{n}$$

Where $t_{0.975}$ = t-value (see table below)

Table of t-Values

n*	$t_{0.975}$	n*	$t_{0.975}$	n*	$t_{0.975}$
2	12.706	7	2.447	12	2.201
3	4.303	8	2.365	13	2.179
4	3.182	9	2.306	14	2.160
5	2.776	10	2.262	15	2.145
6	2.571	11	2.228	16	2.131

* The values in this table are already corrected for n-1 degrees of freedom.
Use n = number of individual values.

6. **Calibration Error**. The calibration error (E_c) will be calculated as follows:

for CO:

$$E_c = \frac{|\bar{d}| + |CC|}{FS} \times 100$$

for O_2: ** $E_c = |\bar{d}| + |CC|$

Where: $|\bar{d}|$ = Absolute value of the mean of differences

$|CC|$ = Absolute value of the confidence coefficient

FS = Full-scale span of monitoring system (for calculation of CO calibration error only)

** For O_2, the calibration error is expressed as % O_2.

Performance Tests

1. **Procedure**. Prior to the test, a reference method (RM) test system will be prepared in accordance with "Guidance on PIC Controls For Hazardous Waste Incinerators," April 1989, and the CEM system will be prepared for operation according to manufacturer's written instructions.

2. **Calibration Error Test**. The first test to be performed is a calibration error test as described in D.7.2.12, Quarterly Calibration Error Test.

3. **Response Time Test**. The next test is a response time test which will be performed as follows:

Zero gas will be introduced into the system. The calibration gases will be introduced at the probe as near to the sample location as possible. When the system output has stabilized (no change greater than 1% of full scale for 30 seconds), the analyzer will be switched to monitor stack effluent. The time (upscale response time) required to reach 95% of the final stable value will be recorded.

Next, a high-level calibration gas will be introduced and the above procedure (stable, switch to sample, stable, record) will be repeated. The entire procedure will be repeated three times and the mean upscale and downscale response time will be determined. The slower or longer of the two means is the system response time.

4. Calibration Drift Test. The system will be in operation continuously for at least one week before this test will be started. The test will be performed while the facility is operating at normal conditions.

During the drift test, no automatic adjustments of the system will be made except those automatic internal adjustments which are part of the automatic compensation circuits integral to the analyzer. The automatic calibration function of the system will be disabled for the duration of the test. The only manual adjustments which will be made to the system will be those mentioned below. Appropriate reference gases will be selected as follows:

- CO measurement
  - Zero reference: ambient air
  - Span reference: 80%-100% of full scale (in N_2)
- O_2 measurement
  - Zero reference: CO span reference gas (0.0% O_2)
  - Span reference: ambient air (20.9% O_2)

At the beginning of the test, the analyzer will be calibrated using the selected zero and span reference gases. After a 24-hour period, the selected zero and span reference gases will be alternately introduced to the system. After stabilization of the readings, the values reported by the system will be recorded. Once both readings have been recorded, the analyzer system will again be calibrated using the selected zero and span reference gases.

This procedure will be repeated every 24 hours for seven days, obtaining eight zero and span values (seven 24-hour readings and the reference gas values). The difference between the reference gas zero and span values and the measured zero and span values may not exceed 5% full span for CO and 0.5% O_2 for any individual set of readings more than once; the average of the seven readings may not exceed these values at all.

5. <u>Relative Accuracy Test</u>. The relative accuracy test will compare measurements of CO concentration measured by RM equipment and CO concentrations measured by the CEM system equipment. The values to be compared will be CO concentrations corrected to 7% volume O_2 (dry basis) and integrated over a sample period of 21 minutes (seven minutes per RM traverse point).

The CEM system output data will be calculated by the control system and automatically printed at the end of each sampling period. The CEM system integrated averaged value will be directly compared to the RM results. The RM CO values will be corrected to 7% O_2 on a dry basis according to RM O_2 data.

At least 12 test runs will be conducted after collection and processing of the data; three sets of test data will be rejected and only the remaining sets will be used for the final calculation of the CEM's relative accuracy. The rejected three sets of data will, however, be recorded and reported along with the other data.

The calculation of the relative accuracy (RA) will be done as follows:

- The mean of RM values for each run will be calculated.
- The mean, standard deviation and confidence coefficient for the differences between RM values and CEM values for the runs used for the final calculations (the equations listed in D.7.2.12 Quarterly Calibration Error Test will be used).
- The relative accuracy will be calculated using the following equation:

$$RA = \frac{|d| + |CC|}{RM} \times 100$$

Where $|d|$ = absolute value of the mean of differences

$|CC|$ = absolute value of the confidence coefficient

RM = average RM value

[Section D.8 has been revised in its entirety]

D.8 INORGANIC TREATMENT SYSTEM

The Inorganic Treatment System, which includes the Reactor Area and Sludge Dewatering System, will be located as shown in Figure D-1-1. The information in this section is presented in accordance with 40 CFR 264 Subpart J with regard to inorganic hazardous waste treatment systems.

D.8.1 General Description

Inorganic treatment generally refers to physical and/or chemical processes whereby inorganic hazardous wastes are rendered non-hazardous or are separated into a concentrated hazardous residue and a non-hazardous effluent. Applicable processes generally fall within three main categories:

- Chemical detoxification;
- Physical separation; and
- Immobilization.

Although a number of chemical and physical processes can be classified as inorganic treatment, there are only a few basic processes that are used extensively. Those few processes are able to handle a wide variety of inorganic wastes in a safe and efficient manner. The proposed inorganic waste treatment system will include only established and well-proven processes for treating inorganic wastes. The Block Flow Diagram for the system used at FFP-LP is shown in Appendix D-5, Drawing 8813-00-F-004. Wastes that cannot be safely and effectively treated by these processes will not be accepted by FFP-LP.

D.8.2 Waste Characterization

The wastes to be received and treated in the inorganic waste treatment system will be inorganic wastes listed as hazardous, including EPA hazardous wastes codes F006, F012, and K062, as well as wastes that are hazardous due to corrosivity (acids and alkalis; waste code D002) and/or toxicity (content of heavy metals; waste codes D004-D011). A complete list of the waste codes may be found in Part A of this application.

Examples of inorganic waste streams that may be treated at the inorganic waste treatment system include the following:

- Aqueous acid solutions containing chromium compounds;
- Aqueous acid solutions such as nitric acid (these may also contain metal compounds);
- Aqueous acid solutions such as hydrofluoric acids and/or fluorides (these may also contain metal compounds);
- Aqueous acid solutions such as hydrochloric acid, sulfuric acid or phosphoric acid (these may also contain metal compounds);
- Photographic developing baths;
- Chromium-containing photographic processing baths (e.g., bleaching, stop, or hardening baths);
- Photographic fixation baths;
- Aqueous alkaline solutions without cyanides (e.g., degreasing baths, metallizing baths);
- Aqueous alkaline solutions containing cyanides;
- Metal hydroxide and/or metal oxide sludges containing one or several metals (e.g., chromium, copper, nickel, zinc, lead, cadmium and silver);
- Flue gas cleaning system sludge from iron and metal foundries which may contain oxides or sulfates of one or several metals (e.g., lead, cadmium, copper, zinc, chromium, nickel, iron, vanadium and aluminum);
- Aqueous sludge from impregnation of wood which may contain copper, arsenic, chromium, and/or fluorine compounds;
- Aqueous acid solutions containing mercury; and
- Aqueous alkaline solutions containing mercury.

The processes to be used to treat the above listed wastes are:

- Cyanide oxidation;
- Chromate reduction;
- Heavy metal precipitation;
- Fluoride precipitation; and
- Neutralization

A detailed list of all wastes to be treated by the inorganic waste treatment system appears in Table C-2 of the Waste Analysis Plan (Appendix C).

D.8.3 Treatment Reactors

There will be four treatment reactors contained in the Reactor Area located in the northern portion of the facility. These reactors are listed in Table D-4-3 in Section D.4.2 and shown in the tank design drawings in Appendix D-3. The secondary containment system and foundation design details of the Reactor Area are provided in Appendix D-5, Drawings 8813-00-M-035 and S-034.

D.8.3.1 Cyanide Reactor

Cyanide-containing waste will be detoxified in a dedicated batch reaction vessel (see Appendix D-3) by oxidation of the cyanide (CN^-) with sodium hypochlorite (NaOCl). The first step of the reaction is as follows:

(a) $H_2O + CN^- + OCl^- <-> ClCN + 2OH^- <-> OCN^- + Cl^- + H_2O$

Cyanate ion (OCN^-) is further oxidized in a second step using sodium hypochlorite:

(b) $2OCN^- + 3OCl^- + 2H^+ -> N_2 + 2CO_2 + 3Cl^- + H_2O$

Reaction (a) is carried out at a pH of 10-11 and reaction (b) is carried out at a pH of 8.5.

The reactions are controlled through continuous monitoring of the pH, redox potential, and temperature of the reaction solution. Furthermore, cyanide (CN^-) content and excess hypochlorite

(OCl^-) content are checked routinely at critical stages of the reaction. The above treatment process will reduce the cyanide content of the waste material to less than 0.5 mg/l. Following cyanide detoxification the pH of the reaction solution will be raised to that required to precipitate heavy metals (typically a pH of 9.8).

The 8,000-gallon reactor will be made of modified polyester fiber reinforced plastic (FRP) that is resistant to alkaline-oxidizing conditions. The reactor will include a cooling loop to remove heat of reaction. In addition, the reactor will never be filled above a specified level so that ample head space volume will remain for emergency cooling by adding water if necessary. Detailed tank data sheets for the cyanide reactor are included in Appendix D-3. Secondary containment for the cyanide reactor will be provided by a concrete system of a base, curbs, and sumps. Containment calculations are included in Appendix D-2 (sheet 5 of 9).

All reactor vessel fill lines will have automatic block valves that are mutually interlocked and also interlocked with the pH monitoring system to prevent acidification of the reactor contents and to eliminate the possibility of gaseous hydrogen cyanide (HCN) production. Fill lines will be top mounted and have dip tubes into the tank. The dip tubes will have siphon holes at the top to prevent back-suction through fill lines.

A breathing vent system will be provided for the reaction vessel which allows in-flow of ambient air to the vessel and the exhaust of cyanide-containing fumes to the common inorganic waste treatment system emission control system. Normal venting of the reaction vessel will occur through a relief valve at a preset pressure/vacuum setting. In addition, constant air flow through the reactor vessel head space will be possible through a bypass around the relief valve. The emission control system for the inorganic waste treatment system is further described in Section D.8.5.

D.8.3.2 Multipurpose Reactors

Three multipurpose reactors will be used to treat all non-cyanide containing wastes, including acidic and alkaline wastes and wastes which contain chromate compounds.

Chromate-containing waste is detoxified by reducing the chromate to soluble chromium (Cr^{+3}) using a reducing agent (e.g., sodium bisulfite). The reduction reaction is:

(a) $2H_2CrO_4 + 3NaHSO_3 + 1.5\ H_2SO_4 <-> Cr_2(SO_4)_3 + 5H_2O + 1.5\ Na_2SO_4$

Soluble chromium (Cr^{+3}) is less toxic than chromate but is still considered toxic. The Cr^{+3} is immobilized through lime precipitation by the following reaction:

(b) $Cr_2(SO_4)_3 + 3Ca(OH)_2 <-> 2Cr(OH)_3 + 3CaSO_4$

Reaction (a) is carried out at a pH of 2-3 and reaction (b) is carried out at a pH of 9.8.

A number of reagents can be used to reduce chromate to Cr^{+3}, and it is likely that some of the wastes received, such as acid wastes containing Fe^{+2}, will be able to serve as reducing agents. To the extent possible and practical, these reducing-agent wastes will be used to treat chromate wastes and thereby minimize the consumption of pure reagents as well as the amount of residues generated.

If sufficient quantities of Fe^{2+} containing wastes are received, the following alternative reaction will be applied to reduce hexavalent chrome:

$2H_2CrO_4 + 6FeSO_4 + 6H_2SO_4 <-> Cr_2(SO_4)_3 + 3Fe_2\ (SO_4)_3 + 8H_2O$

A portion of the non-cyanide-containing wastes treated in the multi-purpose reactors will need only neutralization and precipitation of metals and occasionally removal of fluoride compounds. Lime precipitation of metals and fluoride will be according to the following reaction schemes (precipitated solids are underlined):

$2H^+ + 2F^- + Ca(OH)_2 \rightarrow \underline{CaF_2} + 2H_2O$

$Me^{2+} + Ca(OH)_2 \rightarrow \underline{Me(OH)_2} + Ca^{2+}*$

$SO_4^- + Ca(OH)_2 \rightarrow \underline{CaSO_4} + 2OH^-$

*where Me^{2+} will include in particular the metals shown in Table D-8-1 in Section D.8.4.

Different metals have different optimum pH requirements for precipitation of metal hydroxides. A variety of metals are expected to be present in wastes received at FFP-LP. The optimum pH for lime precipitation of several metal hydroxides simultaneously is generally about 9.8. Figure D-8-1 illustrates the choice of optimum pH.

In certain cases, lime treatment is not sufficient to remove metals by precipitation to concentrations below required levels. This is generally the case for mercury-containing wastes and ammonia-containing wastes, as many metals will form complexes with ammonia. For these wastes, reaction with sodium sulfide and copper sulfate will be used to bring metal concentrations below required levels. The precipitation of metals with sodium sulfide occurs according to the following scheme:

$$Me^{2+} + Na_2S + {}^{*}CuSO_4 \rightarrow \underline{MeS} + 2Na^+ + {}^{**}CuSO_4$$

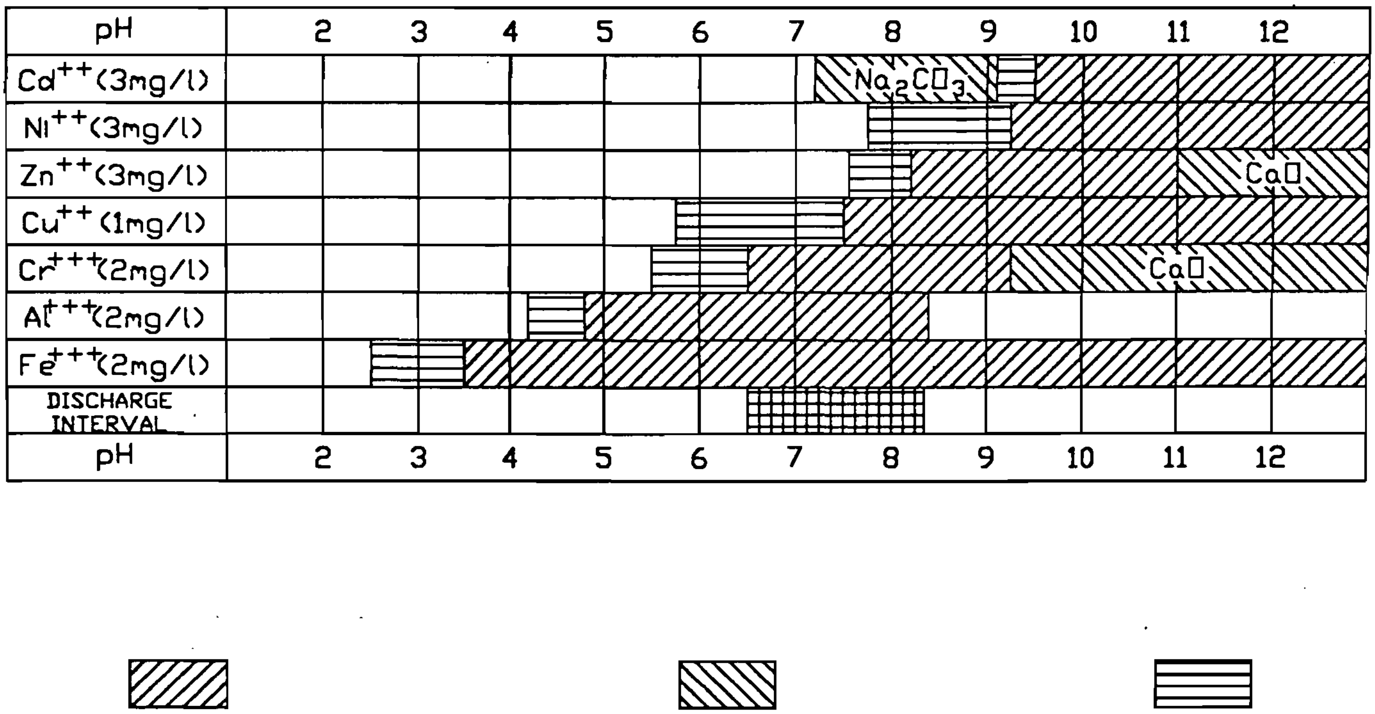
**The $CuSO_4$ will react with any excess Na_2S, preventing release of H_2S.

All reactions conducted in multipurpose reactors will be controlled through continuous monitoring of the pH, redox potential, and temperature of the reaction solution.

The three 8,000-gallon multipurpose reactors will be made of a modified-polyester FRP that is resistant to acidic and alkaline-oxidizing conditions. The reactors will include cooling loops to remove heat of reaction. In addition, the reactors will never be filled above the level specified in Table D-8-7 so that ample head-space volume will remain for emergency cooling by adding water if necessary. Detailed tank data sheets can be found in Appendix D-3. Secondary containment will be provided by a concrete system of a base, curbs, and sumps. Secondary containment calculations are included in Appendix D-2 (sheet 5 of 9).

All reactor vessel fill lines will have automatic block valves that are mutually interlocked and also interlocked with the pH monitoring system to prevent unintentional mixing of wastes/reagents and inadvertent changes in the reaction solution pH. Fill lines will be top mounted and have dip

FIGURE D-8-1
OPTIMUM pH



pH AREA WHERE THE SOLUBILITY OF THE METAL HYDROXIDES IS BELOW THE INDICATED VALUE BY PRECIPITATION WITH NaOH.

INCREASE OF PRECIPITATION AREA BY USE OF CaO OR Na_2CO_3.

START OF PRECIPITATION.

tubes into the tank. The dip tubes will have siphon holes at the top to prevent back-suction through fill lines.

A breathing vent system will be provided for the reaction vessels which allows in-flow of ambient air to the vessels and the exhaust of fumes to the common inorganic waste treatment system emission control system, described in Section D.8.5. Normal venting of the reaction vessels will occur through relief valves at a preset pressure/vacuum setting. In addition, constant air flow through the reaction vessel head space will be possible through a bypass around the relief valve.

D.8.4 Sludge Dewatering

After lime precipitation in the reactors, the slurry is transferred to the sludge dewatering system where separation of the slurry into a filter cake and a filtrate is accomplished. The dewatering system consists of two filter presses, two tanks for filtrate holding, two agitated tanks for slurry feed, and associated pumps and piping. The tanks in this area are listed in Table D-4-3 in Section D.4.2 and shown in Appendix D-3. Secondary containment will be provided for the waste tanks as demonstrated in Appendix D-2 (sheet 4 of 9). Filter cake from the filter presses is transferred to the Filter Cake Loadout Area within the Sludge Dewatering Building. The secondary containment system and foundation design details of this area are shown in Appendix D-5, Drawings 8813-00-M-034 and S-034.

Filter Presses

The filter presses will be of the plate-and-frame type with the following features:

- Top-suspended (hanging) frames for fully automatic operation;
- Electro-hydraulic opening/closing system;
- Closed collecting channels and piping for filtrate and cleaning water;

- Corrosion-resistant materials of construction for all components which contact reaction products; and

- Draw-off tap to permit filtrate water drainage and filter-plate isolation during maintenance or repair.

Two filter press feed pumps will be provided, one of which will be on line and the other of which will be an installed spare. The filter presses will be located in a concrete containment area with a sump to collect leaks or spills. The presses will be equipped with effective plate-moving mechanisms to ensure that the filter cake is discarded each time the plate is moved.

A typical average composition of the filter cake is included in Table D-8-1. The filtrate produced by the system will not exceed the standards in Table D-8-2.

Filter Cake Loadout Area

The Loadout Area will be located on the first floor, below the filter presses. This area is described in Section D.6.5.

D.8.5 Inorganic Treatment System Emission Control and Monitoring System

The inorganic treatment system will include a vent collection system with a common header, and wet caustic scrubber, fans, and stack equipped with a continuous HCN monitoring system. The major vent flow volume will come from the containerized waste handling system vents and from the filter press vents, which will be open only during inorganic treatment system operating hours. Only a small vent flow volume will come from the storage tank vents, reactor tank vents, slurry holding tank vents, and filtrate tank vents. It is expected that during system operating hours the major portion of the vent flow volume to the scrubber will be generated by one of two parallel two-speed centrifugal fans operating at high speed with a maximum capacity of approximately 6,000 scfm. During non-operating hours one of the centrifugal fans will operate at low speed, providing a flow of approximately 1,000 scfm.

TABLE D-8-1

AVERAGE COMPOSITION OF SLUDGE DEWATERING SYSTEM FILTER CAKE

Constituent	Concentration (mg/kg)
$Al(OH)_3$	7,800
$As(OH)_3$	1
$Ba(OH)_2$	30
$Se(OH)_4$	10
$Ca(OH)_2$	16,015
$Cu(OH)_2$	3,992
$Hg(OH)_2$	100
$Cr(OH)_3$	4,160
$Cd(OH)_2$	100
$Pb(OH)_2$	662
$Ni(OH)_2$	75,234
$Ag(OH)_2$	100
$Fe(OH)_3$	68,712
$CaSO_4$	196,343
$CaCl_2$	28,000
Water	600,000

Note: The average filter cake composition is based on the characterization of the filter cake from the inorganic treatment plant at Kommunekemi, Denmark, in which arsenic, barium and selenium were not detected. These metals are expected to be present only in trace amount. This is further evidenced by the actual operating data included in Table D-8-9.

TABLE D-8-2

STANDARDS FOR SLUDGE DEWATERING SYSTEM FILTRATE

Constituent	Standard
pH	8-10
Total chromium (Cr)	0.2 mg/l
Lead (Pb)	5.0 mg/l
Cadmium (Cd)	0.05 mg/l
Zinc (Zn)	0.5 mg/l
Silver (Ag)	0.1 mg/l
Mercury (Hg)	25 ug/l
Phenol	1 mg/l
Arsenic	4 mg/l
Barium	1 mg/l
Selenium	1 mg/l
COD	1000 mg/l
Total cyanide (CN)	0.5 mg/l
F-	10 mg/l
Cl	30,000 mg/l
BOD	100 mg/l
Free Chlorine	0.5 mg/l
Phosphate (as P)	10 mg/l
Ammonia (as N)	25 mg/l
Suspended solids	80 mg/l
Sulphate	5000 mg/l
Toxicity	"Guppy Test" (4 *lebistes reticulati* to survive 24 hours in filtrate diluted 15 times)

Note: The mercury concentration in the filtrate from sulfide precipitation of a batch of mercury-containing waste will be 10-20 μg/l. In the past, however, we have seen the volume of mercury-containing waste to be a minimal portion of the total waste volume. Therefore, with the filtrate from treating non-mercury wastes being mixed with the filtrate from treating mercury wastes, we expect the average concentration to be less than 3 μg/l. Since the waste profile may vary over time, we have assumed mercury to be 25 μg/l. Barium and selenium are expected to occur very rarely and in low concentrations as indicated above.

Vent gases are collected in the vent system manifold and exhausted to the caustic scrubber where the acid components will be neutralized by circulation of a caustic solution. The pH of the solution will be maintained at a value of 8 by adding fresh sodium hydroxide solution. Circulation of the solution through the scrubber sump will be provided by two centrifugal pumps, one on line and the other an installed spare. The scrubber sump volume between the high and low level setpoints will correspond to a minimum 5 minutes scrubber solution residence time at all operating conditions. The minimum distance from lower part of the vent gas inlet nozzle to the high liquid level will be 0.4 times the scrubber diameter.

The inorganic waste treatment system caustic scrubber is designed to control emissions during upset conditions, although such conditions are not expected to occur. Expected characteristics of the vent system exhaust gas during upset conditions are included in Table D-8-3. The expected maximum inlet concentrations to the caustic scrubber listed in Table D-8-3 represent worst-case short-term scenarios that are expected to occur less than once per year. The removal efficiency of the caustic scrubber system for all pollutants except NO_x will be better than 99% under worst-case conditions. Inorganic treatment system emergency release scenarios are further discussed in Section D.8.6.

The operation of the scrubbing system is controlled by the level of liquid in the scrubber sump, the pH of the scrubbing liquid, and the frequency of purging of scrubber liquid. The level of liquid in the scrubber sump is controlled by two switches, a high level switch which stops the addition of process water and a low level switch which starts the addition of process water. The pH of the scrubber liquid is automatically monitored and adjusted by addition of an NaOH solution. In addition, a HCN analyzer and temperature sensor will continuously monitor the vent gas prior to the scrubber, and in the event of a high HCN concentration or temperature an audible alarm will alert personnel, automatically raise the scrubber pH set point to 10, and start both scrubber solution recirculation loops to maintain the 99 percent removal efficiency of the scrubber.

TABLE D-8-3

INORGANIC WASTE TREATMENT SYSTEM
VENT SYSTEM EXHAUST GAS CHARACTERISTICS
DURING UPSET CONDITIONS

	Expected Maximum Inlet Conditions	Expected Maximum Outlet Conditions	Maximum Event Duration	Estimated Event Frequency
Temperature	180°F	160°F	30 minutes	< 1 per year
HCN	6% vol.	0.06% vol.	1 minute	< 1 per year
HF	0.1% vol.	0.001% vol.	30 minutes	< 1 per year
HCL	1.2% vol.	0.012% vol.	30 minutes	< 1 per year
NO_x	3.0% vol.	0.3% vol.	5 minutes	< 1 per year

The design removal efficiency of the inorganic waste treatment system caustic scrubber during upset conditions is >99 percent for all contaminants except NO_x.

The alarm may also be manually activated by the operator. Inorganic waste treatment system emissions during routine operations and upset conditions are further discussed in Section L.

D.8.6 Inorganic Treatment System Emergency Release Scenarios

In order to develop a realistic design basis for the inorganic vent scrubbing system a number of reasonably foreseeable, yet extremely unlikely scenarios have been developed based on concentrations, volumes, temperatures and transfer rates of wastes and reagents.

a. **Hydrogen cyanide (HCN):**

The potential of having an HCN release is extremely unlikely; however, since pH adjustments do occur routinely in the cyanide reactor we will assume the following scenario:

- Maximum 1,300 gallons of cyanide-containing waste in reactor. 1,300 gallons of cyanide-containing waste will be the operational maximum in each treatment batch to allow for addition of reagents and water for dilution and cooling.
- Typically, there will be 0.2% by weight cyanide in the waste. If the waste is higher in cyanide content, dilution down to 0.2% is required in order for the process to work.
- To be conservative, we will assume all the cyanide present in the waste to be reacted to HCN and to be released within 1 minute, (the assumed mixing time requirement for the reaction to take place) to maximize the concentration.

From the above assumptions, the release calculates to be

$$\frac{1{,}300\ \mathit{gallons} \times 9.2\ \mathit{lb/gal} \times 0.002}{1\ \mathit{minute}} = 23.9\ \mathit{lb}/\mathrm{min}^{*} = 1{,}434\ \mathit{lb/hr}$$

$$\frac{23.9\ \mathit{lb}/\mathrm{min} \times 379\ \mathit{scf/lb\ mole}}{26\ \mathit{lb/lb\ mole}} = 350\ \mathit{scfm}^{*}\ \mathit{of\ HCN}$$

With a venting of 6000 scfm this amounts to 6% by volume of HCN.

* This assumes a total release of all HCN gas in 1 minute.

Based on actual vapor/liquid equilibrium data we will develop a more accurate modeling of the amount of HCN that could be released during an emergency event. This will be done during detailed engineering and made available to the Florida DER for review. To give an indication of the degree of conservatism built into the above scenario, note that we have assumed all cyanide to be released during acidification. Actually, HCN is very soluble in water, even more than HCl, which means that at 140°F an aqueous solution can contain more than 30% by weight of HCN. By the same token, HCN is easy to remove in a caustic scrubber and more than 99% removal is easily achievable.

b. Hydrogen fluoride (HF)

For HF the worst case will be the equilibrium concentration of HF above a solution of hydrogen fluoride. Previous experience suggests a HF content in fluoride-containing waste of 3% by weight. At a design temperature of 125°F the equilibrium partial pressure of HF is 0.00725 psi corresponding to 0.05% HF in the gas phase. To be conservative, we will assume 0.1% HF in the gas.

c. Hydrogen chloride (HCl)

For HCl the worst case is based on the following assumptions:

- Two storage tanks being filled with 38% by weight HCl
- Transfer rate for each tank: 220 gpm ~ 30 cfm
- Total vent: 6,000 scfm
- Temperature: 125°F

At the above conditions, the equilibrium partial pressure of HCl is 14.5 psi corresponding to 100% HCl in gas phase. With 60 cfm of 100% gaseous HCl being vented into 6,000 scfm, the resulting HCl concentration will be 1%, and we will assume 1.2% for design. With a transfer rate of 220 gpm and a total tank volume of 8,000 gallons, a duration of approximately ½ hour is assumed.

Note: The largest vent volume will occur during pumping to a tank, and the maximum pump capability is 2 tanks being filled at a rate of 220 gpm each.

d. Nitrous oxide (NO_x)

A 65% HNO_3 solution at 125°F has a NO_x equilibrium partial pressure of 0.19 psi which is less than 1.3% of NO_x. With 60 cfm of 1.3% NO_x being vented into 6,000 scfm, the resulting NO_x concentration will be 130 ppm. A more severe scenario would result from the mixing of a NO_3^- containing waste with a reducing agent such as Fe^{++}, which is commonly found in waste, or the reagent $SO_3^{=}$. The following assumptions have been used in quantifying this scenario:

- Typical NO_3^- content in waste is 0.1% by weight; we will assume 0.2%
- Tank content 8,000 gallons ~ 73,600 lbs
- Mixing time in tank: 5 minutes

NO_x release:

$$\frac{73{,}600\ \mathit{lbs} \times 0.2 \times 379\ \mathit{scf/lb\ mole}}{100 \times 62\ \mathit{lbs/mole} \times 5\ \mathit{minutes}} - 180\ \mathit{scfm}$$

which relative to a total vent of 6,000 scfm is equal to a NO_x content of 3% by volume.

e. Hydrogen sulfide (H_2S):

H_2S or sulfide salts are not expected to be present in the waste. The only potential source for H_2S is sodium sulfide (Na_2S) which is used occasionally as a reagent. Na_2S is only used in those instances where lime precipitation is insufficient, e.g. due to NH_3 complex formation or presence of mercury. The granular Na_2S used in those cases is added in small quantities to the reactor along with copper sulfate which will capture any excess sulfide and avoid H_2S formation.

From the above it is apparent that Na_2S use will be very restricted, and therefore no emergency scenario has been developed.

Some confusion seems to exist regarding the use of sodium bisulfite and Na_2S. To the best of our knowledge, there is no way that sodium bisulfite could generate H_2S. Na_2S is included in the design as a reagent. However, it is not expected to be used on a routine basis, but as a back-up for those instances where treatment standards for metals can not be met by lime precipitation only. This may be the case, for example, when ammonia complexes or mercury are present. If extensive treatment with Na_2S were anticipated, an automatic dosing system would have been incorporated; however, with the very limited use of Na_2S, a manual addition of the granular sulfide salt is proposed. With the reaction being carried out in alkaline solution and with a minimum excess sulfide content being added, we do not see the possibility of any uncontrolled H_2S scenario. Finally the caustic scrubber has a very high affinity for removing H_2S.

D.8.7 Material Balance for Inorganic Waste Treatment System

A material balance has been developed for the inorganic waste treatment system based on the treatment system design and the composition of inorganic wastes expected to be received at FFP-LP. Four general types of inorganic wastes, including cyanide wastes, chromate wastes, acidic and fluoride wastes, and alkaline wastes, are expected to be received at FFP-LP, as shown in Table D-8-4. It is expected that approximately 20 percent of the wastes will be received as solids, and water for dissolving and/or suspending solid inorganic waste material prior to introduction in the reactors is included in the material balance. Reagent usage rates are included in Table D-8-5, and have been estimated based on the treatment reactions discussed in Section D-8-3 of this section, and the characteristics of wastes expected to be received at the facility, as shown in Table D-8-6.

The waste characterization information included in Table D-8-6 is intended to be representative of the general characteristics of wastes treated in the treatment system, and has been used for the purposes of designing the treatment reactors, caustic scrubber, and other components

TABLE D-8-4

INORGANIC WASTE PROFILE (TONS/YEAR)

Waste Type	Pumpable Tank Trucks	Pumpable Drums	Non-Pumpable Dumpsters	Non-Pumpable Drums	Received Total	Water for Dissolving and Suspending	Waste to Reactors
Cyanide	2,580	870	630	210	4,290	1,680	5,970
Chromate	7,710	2,580	1,920	630	12,840	5,100	17,940
Alkaline	2,580	870	630	210	4,290	1,680	5,970
Acids	5,160	1,710	1,290	420	8,580	3,420	12,000
TOTAL	18,030	6,030	4,470	1,470	30,000	11,880	41,880

Assumptions:

20% of wastes are solids
25% of wastes are in drums

TABLE D-8-5

INORGANIC TREATMENT:
REAGENT CONSUMPTIONS (TONS/YEAR)

Reagent	Tons/year
H_2SO_4 (96%)	102
NaOCl (15%)	1,200
Lime (90% CaO)	3,750
$NaHSO_3$ (15%)	600
Na_2S (granular)	<1
$CuSO_4$ (solid)	<1
TOTAL	5,654

TABLE D-8-6

INORGANIC TREATMENT:
SOME TYPICAL WASTE COMPOSITIONS

Cyanide Waste

pH	13.5
Redox potential	-220 mV
CN^-	2 g/l
SO_4^{2-}	7 g/l
Cl^-	15 g/l
Cr (Total)	0.2 g/l
NH_3	0.2 g/l

Chromate Waste

pH	0.2
Redox potential	+450 mV
Cr^{6+}	1.5 g/l
SO_4^{2-}	80 g/l
F-	0.5 g/l
Cl-	100 g/l
NO_{3-}	1 g/l
NH_4^+	1.8 g/l
Fe^{2+}	17 g/l

Acid Waste

pH	0
Redox potential	+330 mV
Fe^{2+}	60 g/l
SO_4^{2-}	120 g/l
F^-	0.1 g/l
NO_3^-	0.3 g/l
Cr^{6+}	$2x10^{-4}$ g/l
NH_4^+	2 g/l

Fluoride Waste

pH	0.1
Redox potential	+450 mV
SO_4^{2-}	50 g/l
F^-	30 g/l
Cl^-	10 g/l
NO_3^-	50 g/l
NH_4^+	10 g/l
Fe (Total)	15 g/l

of the treatment system, and for specification of reagents. The cyanide and multipurpose treatment reactor designs are shown in Table D-8-7. Table D-8-6 is not intended to show the precise composition of each waste type. The compositions of waste received at FFP-LP is expected to vary between generators, and also from one generator shipment to another. All inorganic wastes received at FFP-LP will be characterized in accordance with the Waste Characterization and Waste Analysis Plan previously discussed in Section C of the Application. Wastes that are determined to be inappropriate for treatment in the inorganic waste treatment system, based on the treatment system design and reagent specifications, will not be treated.

An overall material balance for the inorganic waste treatment system is shown in Table D-8-8. Sludge and filtrate generation rates and composition are based on the characteristics of wastes expected to be received and reagents expected to be used in the treatment system, the major chemical reactions that will occur in the reactors, and the dewatering efficiency of the filter press. Filtrate water will be reused in the inorganic waste treatment system and incinerator air pollution control systems, and will not be discharged. Additional waste and treatment residue data from a similar facility has been included as Table D-8-9 for reference. It is only intended to show typical values and does not represent average or limiting values for the wastes expected at the FFP-LP facility.

D.8.8 Summary of Safety Features

The preceding sections have described the safety features that have been incorporated at the various stages of unloading, transfer, storage, treatment and discharge. The following is a brief summary of those features to give an overall view of the safety of the inorganic treatment system.

- Dedicated unloading, piping, pumps and storage tanks will be provided for the four waste categories: cyanide, alkaline, acidic and chromate wastes. Written procedures backed up by a pH-based interlock will prevent wastes from being unloaded into an incompatible storage area.

TABLE D-8-7

INORGANIC TREATMENT: REACTOR DESIGN

Waste Type	Reactor	Waste Per Batch* (8,000 gal reactors)	Estimated Batches/Year	Days Required/Year**
Cyanide	Cyanide	1,300 gal/14,080 lbs.	848	141
Chromate	Multipurpose	2,000 gal/17,600 lbs.	2,039	227
Alkaline	Multipurpose	2,000 gal/17,600 lbs.	678	227
Acids	Multipurpose	2,000 gal/17,600 lbs.	1,364	227

*Cyanide waste per batch: 20% of reactor volume
Chromate, alkaline and acid waste per batch: 25% of reactor volume

**A complete batch cycle will be 4 hours and a working day is 24 hours.

TABLE D-8-8

INORGANIC TREATMENT: OVERALL BALANCE (TONS/YEAR)

Incoming:	
Waste Received	30,000 tons/yr
Reagents	5,654 tons/yr
Water	53,100 tons/yr
TOTAL	88,754 tons/yr
Outgoing:	
Filter cake	15,000 tons/yr
Filtrate*	73,754 tons/yr
TOTAL	88,754 tons/yr

*To be reused in APC system.

- Mixing of different waste categories and reagents is only possible in the four reactors (only in one reactor for cyanide waste). To ensure controlled mixing in the reactors and to minimize human error, extensive batch sequencing logic will be implemented in the control system. This will virtually make it impossible to mix incompatible wastes. In order for the batch logic system to allow waste or reagent transfer proper pH, electrochemical potential, temperature, level, valve position and other criteria must be satisfied. In addition, the transfer has to follow the prescribed batch treatment sequence. The facility engineer will define this sequence and enter it into the computer.
- External heat exchangers and direct water addition to the reactors will prevent temperature excursions.
- In the unlikely event that the above features should fail and an unintentional mixing of wastes and/or reagents should occur, leading to a release of harmful vapors, an emission control system, including a caustic scrubber, will remove 99% of HF, HCl and HCN vapors.

During detailed design, engineering documents describing the above in full detail will be developed and made available to the Florida DER for review.

Table D-8-9

FACILITY WASTE CHARACTERIZATION*

Parameter	Electroplating Waste	Waste Water Neutral Sump	Waste Ferrous Acid	Waste Chromic Acid	Waste Nitric Acid	Sulfide Containing Waste	Reaction Tank Composite
VOLUME (gallons)	4770	1974	1200	100	140	5	10,193[(b)]
VOLATILE ORGANIC COMPOUND (mg/kg)	NS	NS	NS	NS	NS	NS	.340
1,1-dichlotoethane	NS	NS	NS	NS	NS	NS	.220
1,1,1-trichloroethane	NS	NS	NS	NS	NS	NS	.99
Trichloroethane	NS	NS	NS	NS	NS	NS	.074
1,1,2,2-tetrachloroethylene	NS	NS	NS	NS	NS	NS	.140
Toluene	NS	NS	NS	NS	NS	NS	.200
Ethylbenzene							
METALS (mg/kg)							
Arsenic	<1	<1	<1	<1	3	<1	<1
Barium	<10	<10	<10	<10	<10	<10	<10
Cadmium	19	<5	<5	7	<5	<5	10
Chromium	760	470	7,000	103,800	1,800	7	2311
Lead	125	250	<10	60	<10	12	108
Mercury	<1	<1	<1	<1	<10	<1	<1
Selenium	<10	<10	<10	<10	<1	<10	<10
Silver	<2	<2	<2	<2	<2	<2	<2
Hexavalent chromium	0.016	0.148	I	78,400	I	0.016	0.1
Copper	36	40	306	3,500	865	<3	72
Nickel	14	355	2,600	40	3,200	<3	426
Zinc	190	410	<2	250	<2	9	171

(b) - In addition to the components listed includes 1445 gallons of lime slurry and 559 gallons of water washes.

NS - Not sampled

I - Analytical color interference

* - Data from a typical inorganic treatment plant, referenced in "Characterization of Treatment Residues from Hazardous Waste Treatment, Storage and Disposal Facilities" by Metcalf and Eddy, Inc. (EPA Contract 68-03-3166)

Table D-8-9 (Cont.)

FACILITY RESIDUAL CHARACTERIZATION

Parameter	Filtered Effluent	Filter Cake	EP Toxity	TCLP	Land Disposal Regulations
VOLATILE ORGANIC COMPOUND (mg/l)					
1,1-dichloroethane	<0.01	0.340*	NA	0.022	None
1,1,1-trichloroethane	<0.01	0.470*	NA	0.017	30
Trichloroethylene	<0.01	0.130*	NA	<0.01	0.07
1,1,2,2-tetrachloroethylene	<0.01	0.150*	NA	<0.01	None
Toluene	<0.01	0.230*	NA	0.017	14.4
Ethylbenzene	<0.01	0.390*	NA	0.017	None
METALS (mg/l)					
Arsenic	<0.1*	1*	<0.05	<0.01	<5.0
Barrium	<1*	30*	0.02	0.18	<100
Cadmium	<0.5	20*	0.0008	<0.02	1.0
Chromium	0.12	16,300*	<0.01	<0.05	5.0
Lead	<0.01	375*	0.08	0.10	5.0
Mercury	0.1	<1*	<0.002	0.002	0.2
Selenium	<1*	<10*	<0.01	<0.01	1.0
Silver	<0.2*	<2*	0.01	<0.02	5.0
Hexavalent Chromium	0.121	I	<0.005	0.01	None
Copper	0.16	330*	0.05	NS	None
Nickel	0.40	1,700*	0.10	NS	None
Zinc	0.115	375*	0.01	NS	None

N/A - Not applicable

NS - Not sampled

I - Analytical color interference

* - Units are in mg/kg

Section D.9 has been revised in its entirety

D.9 STABILIZATION SYSTEM

Stabilization of process residuals generated on-site will be conducted at the Stabilization Area located in the middle of the FFP-LP facility as shown in Figure D-1-1. This process will result in immobilized hazardous waste constituents which will pose less of a threat to public health and the environment.

D.9.1 Selection of Stabilization Process

Stabilization is a chemical or thermal process in which special chemical binding agents or energy are added to a waste to reduce or eliminate migration of toxic components through or from the stabilized final waste form. An effective stabilization process should produce a good strength (300-1500 psi), nonleachable, and durable final product that resists aging and weathering and is suited for permanent disposal. Waste materials, once stabilized, are in a final form such that toxic constituents do not pose a significant threat to the environment or to human or aquatic life.

The terms solidification, immobilization, and stabilization are often used interchangeably, but they have different applications.

Solidification is the addition of dry components to a waste to produce a hardened final product that contains no free water. This hardened final product does not necessarily retain or immobilize the mobile toxic components.

Immobilization is the addition of components to retain the toxic components in the final matrix. The final form may be a low-strength material, with no definable shape.

Stabilization is the addition of chemical binders to a waste to produce a hardened final product that effectively immobilizes the toxic constituents present in the waste.

There are numerous stabilization technologies and processes that are available and suitable for one or more specific waste types, and each process has specific applications and advantages. Only cement-based stabilization, however, is considered by FFP-LP to have the flexibility to handle a wide variety of waste, to be compatible with low-cost standard equipment, and to be capable of stabilizing almost all toxic constituents and producing a high-strength, nonleachable, durable, and delistable final product. The stabilization process selected for the FFP-LP facility, cement-base (grout) stabilization, will render metal hydroxide sludges and the kiln ash produced at FFP-LP into a concrete stabilized final product that is an environmentally acceptable form for permanent disposal.

The lime-base process, the gypsum cement process (e.g., Environstone), and the bitumen process were not selected by FFP-LP, as each of these stabilization processes are suited only to specific waste types and will not stabilize certain toxic materials; produce lower-strength final products than cement stabilization; require special, more expensive, proprietary or priority-treatment chemicals and additives; or require special expensive equipment. Thermal stabilization or vitrification involves heating wastes to extremely high temperatures. Water and volatile components are driven out of the waste, leaving the toxic constituents stabilized in a molten pool of glass or slag. Energy demands and cost make vitrification suited for only the most toxic or radioactive wastes and therefore this technology was not selected by FFP-LP.

D.9.2 Chemistry of Stabilization and Process Chemistry

Cement-base stabilization is a well recognized, proven process with an outstanding track record. This process uses standard, readily available off-the-shelf equipment and chemicals. There are no proprietary or priority ingredients, and all stabilization chemicals are available in bulk quantities at moderate costs. It is a low-energy, low-temperature process. The stabilized waste forms produced are resistant to physical, biological, chemical, thermal, and radiation degradation and are easily moved, handled, stacked, stored, and buried. There is no free liquid or drip water produced and minimal generation of fugitive dust or fumes, and high waste loadings are achieved with minimum increase in final volume. With optimized grout formulations, the final volume should not be more than 25-30% greater than the original waste volume. The process readily stabilizes solids, sludges, ashes, and liquids.

Cement-based stabilization complies with all State and Federal regulations and permitting requirements. This process produces a final concrete waste form that may qualify for delisting from hazardous to non-hazardous. At this time, however, this permit application does not include a delisting petition. A petition to exclude the stabilized waste residue from lists in 40 CFR 261 Subpart D may be submitted at a later date if the characteristics of the residue are verified and demonstrated to be non-hazardous.

There is no one generic stabilization formulation or set of treatment chemicals that is best suited for all waste types and that will provide maximum stabilization at minimum cost and minimum final volume; each type of waste requires its own recipe. Normally, after careful review of all chemical characterization data for a specific waste to be stabilized, treatment chemicals and additives are selected that are compatible and are best suited for stabilizing the most mobile toxic species in that particular waste. Also, set retarders and accelerators and any interfering metals or anions are identified and treated in the stabilization formulation. Next, the ratio by weight of dry treatment chemicals to waste material is determined and the amount of additive is selected. From this information a trial formulation specification is written.

Normal procedure requires that this formulation be tested on a laboratory-size test pour using the actual waste. The stabilized test cubes that are generated are tested for compressive strength, leachability, and durability. The data from these tests and information regarding the handling and processing characteristics of the wet laboratory concrete are used to adjust the stabilization formulation by addition of other treatment chemicals, binders, and additives. When test results are acceptable, the original stabilization chemicals and additives remain the same for the final recipe and only the ratio of dry blend chemicals to waste may change. The compatibility of the stabilization facilities' equipment, the stabilization formulation, and the facilities' process flow will need to be proven and demonstrated for each waste type.

Metals hydroxide sludge and the kiln ash generally will be stabilized using a blend of Portland Type I cement and ash. An air-entraining non-volatile liquid admixture will be used to improve processability and flow properties. Other stabilization chemicals such as blast furnace slag, kiln dusts, clays, silicates, set accelerators, and set retarders will not generally be necessary to stabilize these wastes. The role that cement, ash, and the admixture play in the stabilization process are described in the following.

Cement

Cement is the primary binding material which forms the final solid concrete matrix. Portland cement (there are several types and each has its own specific application) consists of a mixture of calcium silicates, aluminates, and aluminoferrites which react exothermically with water, at different rates, to form complex hydrates and calcium hydroxide. Although the chemistry of Portland cement is very complex, it is known that the rate at which these complex hydrates are formed greatly affects the mechanical properties of the final solid matrix. Some components, especially certain organics and anions like chloride, greatly alter the rate at which cement hydrates and consequently change the mechanical properties of the final waste form. Set or hardening occurs in the presence of a sulphate retarder in a few hours, and strength gain follows. The amount of water added should be sufficient to enable the wet concrete mass to flow. Normally, a water/cement (w/c) ratio of 0.35-0.60 is required for waste stabilization, but it may be as high as 1.0 for certain wastes. Undried concretes contain water in excess of that required for hydration. The product consists of a solid matrix of hydrated silicates, hydrated aluminates, and aqueous pore fluid. During exposure to ground water, or leaching, concretes contain much more pore fluid and the solid silicate portion is in constant intimate contact with the pore fluid. Therefore, it is most important that the cement blend formed in the stabilization process generates insoluble reaction products to encapsulate the toxic constituents in the waste material.

Ash

Ash is used as a supplemental binding agent or cement extender that has a positive effect on concrete strength and has been used successfully for many years in the construction concrete industry as a partial replacement for cement. Class F ash contains a minimum of 70 wt% SiO_2, Al_2O_3, and Fe_2O_3. All chemical and physical requirements for ash used in concrete construction are given in American Society for Testing and Materials (ASTM) C 618. Class F ash has a low calcium content and is non-hydraulic, but in the presence of water it combines with lime at ambient temperatures to produce cementitious products. Class F ash has latent cementitious properties that contribute to the concrete's final strength, act as a diluent to slow early hydration, and give lower heats of hydration. Ash greatly improves the flow properties of the wet grout, gives improved chemical stability, and substantially lowers leach rates in the hardened concrete.

Admixture

Air-entraining admixtures give optimum air content to concretes. This increased optimum air content in the concrete results in the following improvements in concrete quality: (1) increased resistance to cracking and spalling from freeze/thaw weather cycles, (2) reduced permeability and increased water tightness which should reduce leaching, (3) reduced segregation and bleeding, and (4) improved plasticity and flow properties. Non-volitile liquid admixtures will be used in the stabilization process.

D.9.3 Process Description

The process design for the FFP-LP Stabilization Area includes equipment for handling, storage, pre-treatment, fixation, and casting of rotary kiln ash and metal hydroxide sludge. The process is designed to produce a final product which can be delisted and to minimize liquid discharges by recycling as much waste/rinse water as possible. The secondary containment system and foundation design details are provided in Appendix D-5, Drawings 8813-00-M-024, S-017, and S-018. The calculations which demonstrate that this area will be equipped with adequate secondary containment are provided in Appendix D-2 (sheet 9 of 11).

The area will provide equipment for receiving kiln ash and metal hydroxide sludges, pre-treating, weighing, and mixing it with the appropriate quantities of ash, cement, water, and admixture to form a grout mixture. This mixture will be cast into 5'-6" x7' x4'-6" metal boxes. Except for casting and filling of the ash/cement silos, all operations will be controlled remotely from the central control room. A data acquisition system will be included to facilitate record keeping.

Kiln Ash System

The kiln ash will be transferred in lugger boxes directly from the rotary kiln ash discharge system to a crusher. The crusher will reduce extraneous material to a size less than 1/4 inch at the rate of 10 yd^3/hr. After crushing, the kiln ash will fall into the receiving bin, from where the waste will be transferred via a clamshell/crane to a weigh scale and then by gravity to the high-energy mixer. The receiving bin will be a 30-yd^3 concrete bin. The weigh scale will have an 8 yd^3 capacity and a range of 0 to 16,000 pounds.

Metal Hydroxide System

The metal hydroxide sludges will normally be received in lugger boxes from the dewatering station and will be dumped into the receiving bin. The transfer of the metal hydroxide from the receiving bin to the weigh scale is accomplished by a clamshell/crane. This weigh scale will have an 8 yd^3 capacity with a zero to 16,000 lb weighing system. After weighing the sludge will flow from the weigh scale to the high-energy mixer by gravity.

Cement/Ash System

Both the ash and the cement systems have their own independent 200-yd^3 storage silos and 50-yd^3 day silos. Ash and cement will be received at the facility by transport trucks and pneumatically transferred to the storage silos. The cement and ash will be transferred to the day storage tanks pneumatically. The cement day silo will be divided into two compartments of 25 yd^3 each. The appropriate amounts of cement and ash will be transferred by gravity to a common batcher (weigh scale). This scale will be capable of weighing from 0 to 10,000 lbs. and have a capacity of 5 yd^3. Transfers will be assisted by aerators and vibrators. All silos and batchers will be fitted with baghouses for removal of particulates.

Admixture System

The admixture will be added to the high-energy mixer from a 1,500-gal polyethylene tank. A 4 gpm metering pump will transfer the material through a flow meter so the exact quantities added to the mixer can be controlled.

Water Addition System

Water will have to be added to kiln ash as well as the metal hydroxide sludge. The amount of water added will be controlled via a flow meter.

High Energy Mixer

After the cement, ash and sludge or kiln ash is weighed, it is transferred into the high energy mixer. At this time, admixture and water (if needed) are added to the mixer. The material is then homogenized in less than 5 minutes after all ingredients are added. A baghouse will be included for control of particulates.

The high energy mixer has a total volume of 10.5 yd^3 and a working volume of 7 yd^3. The mixer is driven by a variable-speed motor. Mixing is accomplished by a plough which forces all components, at high velocities, both axially and radially through the mixer. The mixer shall have an emergency dump with an auxiliary emergency drive system so the mixer can be emptied if a power failure or malfunction should occur. The grout is transferred by gravity from the mixer to the casting boxes.

Casting

The fixed waste will be poured from the mixer directly into a 5.9 yd^3 (5'-6" x 7' x 4'-6) steel box. The boxes will be structurally sound and tested for moving and stacking with a fork lift while full. Removable vibrators will be mounted on the boxes so the grout will be distributed evenly throughout the box.

Steel boxes were chosen over drums and forms for the following reasons:

- Increased production rates (101 yd^3/day vs 37 yd^3/day)
- Reduced labor
- Less spillage because one batch fills a single box.
- Long term containment (5 to 10 years) of waste
- Movement and stacking before mix is cured
- Complete filling of boxes provides strong support for stacking
- Increased packing efficiency with rectangular containers - requires 25% less storage or landfill space than drums

Forklift

A 12-ton forklift with pneumatic all-terrain tires will be used to handle the boxes.

Process control

The area will be operated remotely from the central control room. The weights, mix times, totalizer reading, and transfer time of all critical parameters will be recorded by a computer system.

Wash water

The processing of a grout mixture, like standard construction concrete, requires a considerable amount of water to wash equipment. This is absolutely necessary to prevent hardening which causes equipment damage and downtime. The wash water will be collected in a sump and recycled back to the stabilization process.

Section D.10 is a new section

D.10 INCINERATOR ANNUAL PERFORMANCE TEST PROTOCOL

Approximately one year after the facility receives its final operating permit (including the results of the trial burn) and every year thereafter, the incineration system will be subjected to an annual performance test. The purpose of this test is to demonstrate the continuing capability of the incineration system in the following areas:

- POHC DRE of at least 99.99%
- HCl removal efficiency of at least 99%
- Particulate emissions not greater than 0.02 gr/dscf
- Metals emissions not greater than those in Table 2.5-5 of the Trial Burn Plan

This test will be conducted using actual hazardous wastes available on site when the test is scheduled. A single volatile POHC will be added to the high-Btu liquid waste stream to determine the incinerator system DRE. A solution of 10 metals will be injected into the low-Btu liquid stream. The specific POHC to be used for the performance test will be specified to and approved by FDER prior to conducting the test. The test conditions will be approximately those of trial burn Test 2 (see Section 1.7.3 of the Trial Burn Plan).

D.10.1 Estimated Operating Conditions

Table 1 lists the estimated operating conditions.

D.10.2 Sampling and Analysis

See Tables 2 and 3 for the proposed sampling and analysis methods and locations. These are essentially identical to those proposed in Trial Burn Section 2.0.

D.10.3 Process Monitoring

See Table 4 and Drawing 8813-00-F-017 for the proposed process monitoring locations.

Table 1
Estimated Operating Conditions

KILN PARAMETERS				
Waste type Waste feed, lb/hr No. of containers/hr	Low-Btu Liq. 2,000 --	High-Btu Liq. 500 --	Solids 1,000 10	Sludge 8,300 --
Exit temperature, °F	2,200			
Waste heat release, MM Btu/hr	71.94			
Aux. fuel heat release, MM Btu/hr	0.00			
Total heat release, MM Btu/hr	71.94			
Excess air, percent	63			
SCC PARAMETERS				
Waste type Waste feed, lb/hr	Low-Btu 3,500	High-Btu 250		
Exit gas temperature, °F	1,800			
Waste heat release, MM Btu/hr	2.99			
Aux. fuel heat release, MM Btu/hr	0.00			
Total SCC heat release, MM Btu/hr	2.99			
Gas residence time, sec.	2.71			
Total system heat release, MM Btu/hr	74.93			
SCC DISCHARGE				
HCl loading, lb/hr	1,202			
Dry vol. $\%O_2$	8.3			

Table 2
Process Stream Sampling and Analysis Scheme

Sample Type/Location[1]	Sampling Method	Frequency of Sampling for Each Run	Analysis[2]	Analytical Method
1. Bulk Solids Feed	Scoop (S007)	Two 100-g grab samples every hour composited into two samples at end of run	Composition[3] Heating Value Metals POHC	ASTM method D3176 ASTM D2015-85 SW-846 method 7000 SW-846 method 8010
2. Containerized Waste Feed	Scoop (S007)	Two 200-g grab samples during feed preparation	Composition[3] Heating Value Metals POHC	ASTM method D3176 ASTM D2015-85 SW-846 method 7000 SW-846 method 8010
3. Fuel Oil	Tap (S004)[4]	Two 100-ml grab samples and one 40-ml VOA vial every 15 minutes composited into three samples at end of run	Composition[3] Density Viscosity Heating Value Metals POHC	ASTM method D3176 ASTM D-4052 ASTM D-88-81 ASTM D2015-85 SW-846 method 7000 SW-846 method 8010
4. High-Btu Liquid Feed	Tap (S004)[4]	Two 100-ml grab samples and one 40-ml VOA vial every 15 minutes composited into three samples at end of run	Composition[3] Density Viscosity Heating Value Metals POHC	ASTM method D3176 ASTM D-4052 ASTM D-88-81 ASTM D2015-85 SW-846 method 7000 SW-846 method 8010

1. See Drawing 8813-F-017.
2. Not including additional quality control analyses.
3. Composition includes C, H, O, N, S, Cl, F, ash and moisture.
4. A003, S004 and S007 methods are from "Sampling Methods for Hazardous Waste Incinerators," first edition.

Table 2
Process Stream Sampling and Analysis Scheme (Cont.)

Sample Type/Location[1]	Sampling Method	Frequency of Sampling for Each Run	Analysis[2]	Analytical Method
5. Low-Btu Liquid Feed	Tap (S004)	Two 100-ml grab samples and one 40-ml VOA vial every 15 minutes composited into three samples at end of run	Composition[3] Density Viscosity Heating Value Metals POHC	ASTM method D3176 ASTM D-4052 ASTM D-88-81 ASTM D2015-85 SW-846 method 7000 SW-846 method 8010
6. Sludge Feed	Tap (S004)	Two 100-ml grab samples every 15 minutes composited into two samples at end of run	Composition[3] Density Viscosity Heating Value Metals POHC	ASTM method D3176 ASTM D-4052 ASTM D-88-81 ASTM D2015-85 SW-846 method 7000 SW-846 method 8010
7. Process Water	Tap (S004)	Two 100-ml grab samples and one 40-ml VOA vial every 60 minutes, composited into three samples at end of run	Total chloride Metals POHC	A003 SW-846 method 7000 SW-846 method 8010
8. Rotary Kiln Ash	Scoop (S007)	Two 100-g grab samples every hour composited into two samples at end of run	Metals POHC	SW-846 method 7000 SW-846 method 8010
9. Ash Quench Blowdown	Tap (S004)	Two 100-ml grab samples and one 40-ml VOA vial every 60 minutes composited into three samples at end of run	Total Chloride Metals POHC	A003 SW-846 method 7000 SW-846 method 8010
10. Lime Slurry Feed	Tap (S004)	Two 100-ml grab samples and one 40-ml VOA vial every 60 minutes composited into three samples at end of run	Total Chloride Metals POHC	A003 SW-846 method 7000 SW-846 method 8010

1. See Drawing 8813-F-017.
2. Not including additional quality control analyses.
3. Composition includes C, H, O, N, S, Cl, F, ash and moisture.
4. A003, S004 and S007 methods are from "Sampling Methods for Hazardous Waste Incinerators," first edition.

Table 2
Process Stream Sampling and Analysis Scheme (Cont.)

Sample Type/Location[1]	Sampling Method	Frequency of Sampling for Each Run	Analysis[2]	Analytical Method
11. Dried Solids	Scoop (S007)	Two 100-g grab samples every hour composited into two samples at end of run	Metals POHC	SW-846 method 7000 SW-846 method 8010
12. Stack Gas	See Table 2	3-hr composite	See Table 2	See Table 3
13. Inorganic Filtrate	Tap (S004)	Two 100-ml grab samples and one 40-ml VOA vial every 60 minutes, composited into three samples at end of run	Total chloride Metals POHC	A003 SW-846 method 7000 SW-846 method 8010
14. POHC	Tap (S004)	One VOA vial per batch	POHC	SW-846 method 8010
15. Metals Solution	Tap (S004)	One 250 ml grab sample per batch	Metals	SW-846 method 7000

1. See Drawing 8813-F-017.
2. Not including additional quality control analyses.
3. Composition includes C, H, O, N, S, Cl, F, ash and moisture.
4. A003, S004 and S007 methods are from "Sampling Methods for Hazardous Waste Incinerators," first edition.

Table 2
Process Stream Sampling and Analysis Scheme (Cont.)

Sample Type/Location[1]	Sampling Method	Frequency of Sampling for Each Run	Analysis[2]	Analytical Method
11. Dried Solids	Scoop (S007)	Two 100-g grab samples every hour composited into two samples at end of run	Metals POHC	SW-846 method 7000 SW-846 method 8010
12. Stack Gas	See Table 2	3-hr composite	See Table 2	See Table 2
13. Inorganic Filtrate	Tap (S004)	Two 100-ml grab samples and one 40-ml VOA vial every 60 minutes, composited into three samples at end of run	Total chloride Metals POHC	A003 SW-846 method 7000 SW-846 method 8010
14. POHC	Tap (S004)	One VOA vial per batch	POHC	SW-846 method 8010
15. Metals Solution	Tap (S004)	One 250 ml grab sample per batch	Metals	SW-846 method 7000

1. See Drawing 8813-F-017.
2. Not including additional quality control analyses.
3. Composition includes C, H, O, N, S, Cl, F, ash and moisture.
4. A003, S004 and S007 methods are from "Sampling Methods for Hazardous Waste Incinerators," first edition.

Table 3
Stack Sampling and Analysis Parameters[1]

Test Parameters	Sample Methods	No. of Samples Collected	Analyzed	Analytical Method
O_2 and CO_2	EPA M3	3	3	Orsat
CO	EPA Performance Specification	Continuous	Continuous	Continuous NDIR Emissions Monitor
Particulate/HCl	EPA M5-P	3	3	Gravimetric/Ion Chromatography
Metals	Multiple Metal Method (M5-M)	3	3	SW-846-6010
Volatile POHCs	VOST (SW-846-0030)	4	3	SW-846-5040, 8240

[1] Blank samples are not included in this table.

D.10.4 Results Reported

Results will be reported in a manner similar to that discussed in Section 1.9 of the Trial Burn Plan. The key results will include:

- DRE for single POHC
- APC system efficiency for HCl
- APC system efficiency for SO_2
- Rolling average CO exhaust gas concentration
- Average THC exhaust gas concentration
- Total particulate (PM-10) exhaust gas concentration
- Total emissions and removal efficiency of EPA-listed metals

Table 4
Summary of Process Monitoring During Test

Parameter	Location of Monitor	Type of Monitor	Operating Range	Permanent Recorder
Bulk Solids Weight	15A-crane/clamshell 15B-feed conveyor	Load Cells	0-3,000 lb 0-6,000 lb	Yes Yes
Containerized Waste Weight	16-automatic weigh sealant feed conveyor	Load Cells	0-1,000 lb	Yes
Fuel Oil Flow Rate	17A-line to burner on kiln 17B-line to burner on SCC	Mass Flowmeter	0-10 gpm 0-10 gpm	Yes
High-Btu Liquid Waste Feedrate	18A-feed line to burner on kiln 18B-feed line to burner on SCC	Mass Flowmeter	0-10 gpm	Yes
Low-Btu Liquid Waste Feedrate	19A-feed line to nozzle on kiln 19B-feed line to nozzle on SCC	Mass Flowmeter	0-15 gpm	Yes
Sludge Feedrate	20-feed line to nozzle on kiln	Mass Flowmeter	0-15 gpm	Yes
Combustion Air	22A-air inlet duct to kiln 22B-air inlet duct to SCC	Thermal Dispersion Flowmeter	0-50,000 acfm 0-25,000 acfm	No
Rotary Kiln Pressure (Draft)	23 kiln outlet	Pressure Transducer	-2 to 1" wc	Yes
Rotary Kiln Speed	24-kiln rollers	Tachometer	0-1.5 rpm	No
Rotary Kiln Temperature	25-kiln outlet	Type-R Thermocouple	0-3,000°F	Yes
SCC Temperature	26-SCC outlet	Type-R Thermocouple	0-3,000°F	Yes
SCC Pressure (Draft)	27-SCC outlet	Pressure Transducer	-2 to 1" wc	No
SDA Temperature	29-SDA outlet	Type-J Thermocouple	0-600°F	Yes

Table 4
Summary of Process Monitoring During Test (Cont.)

Parameter	Location of Monitor	Type of Monitor	Operating Range	Permanent Recorder
Absorber Slurry Feedrate	30-recycle pump discharge	Magnetic Flowmeter	0-100 gpm	No
Fabric Filter Pressure Differential	31-fabric filter	Pressure Transducer	0-10" wc	Yes
Oxygen	32-stack	Paramagnetic	0-25 percent	Yes
Carbon Monoxide	32-stack	NDIR	0-500 ppm	Yes
Hydrogen Chloride	32-stack	Specific Ion or NDIR	0-250 ppm	Yes
Total Hydrocarbon	32-stack	FID	0-100 ppm	No
Combustion Gas Flow Rate	32-stack	Thermal Dispersion	0-90,000 acfm	Yes

APPENDIX D-2

Add to appendix

INTERNATIONAL WASTE ENERGY SYSTEMS
2150 KIENLEN AVENUE ST. LOUIS, MISSOURI 63121
TELEPHONE (314) 389-7275 TELEX 44-2438

PROJECT NO. 8813 INDEX NO.
REV. NO.
SUBJECT FLORIDA FIRST PROCESSING INC MADE BY KL DATE 1/5/89
BULK SOLIDS CONTAINMENT CHECKED BY DATE

REF. DWG. # S-008, S-009

HOPPERS

3 EA. – BULK SOLIDS RECEIVING TANKS 15' × 15 INSIDE

15.0' × 15.0' × 12.5' = 2812 ft³
– 1.75' × 3.0' × 1/2 × 4 × 13.25' = –139
2673 ft³ @ 0.110 k/ft³ = 294k

BASE: 16.0' × 17.0' × 1.5' × 0.15 = 61.2k
BEVELS: FROM ABOVE 139 ft³ × 0.15 = 20.8
WALLS: 1.0' × 11.5' × 15.0' × 0.15 = 25.9
1.25' × 16.0' ((3.0' + 4.5')/2) 0.15 = 11.3
119.2k — 119

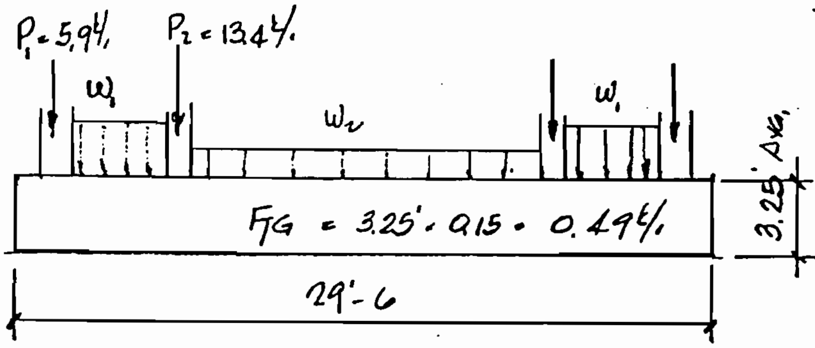
413k

COL. LOAD: ROOF LOAD @ 40 #/ft
27'-6 FL. LOAD @ 135
175 #/ft × 16.0' × 27.5'/2 = 38.5k — 40k

SEE SKETCH BELOW:

P_2 = CURB 0.67' × 1.0 × 0.15 = 0.10 k/'
SLAB 1.0' × 4.0'/2 × 0.15 = 0.30
LOAD ABOVE = 413k ÷ 2 × 16' = 12.91
13.4 k/'

P_1 = WALL 1.25' (20' – 3.25') 0.15 = 3.1 k/'
COL. LD 40k ÷ 16.0' = 2.5
SLAB (SEE ABOVE) = 0.3
5.9 k/'



ASSUME VOIDS FULL W/ WATER:
w_1 = 0.0625 × 15.75' = 0.98 k/'
w_2 = 0.0625 × 3.75' = 0.23 k/'

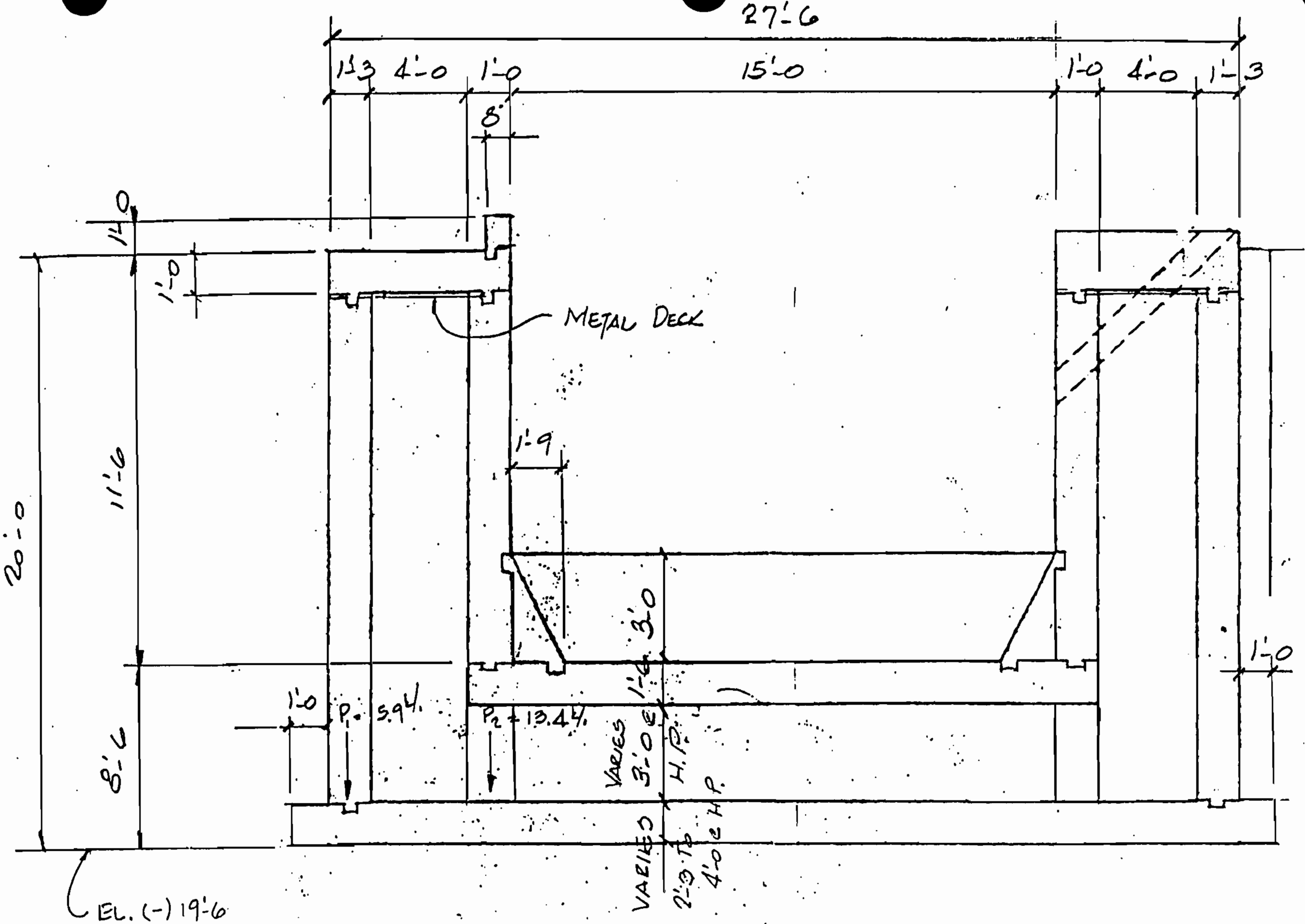
SOIL PRESSURE = (5.9k/' + 13.4k/' + 0.98k/' × 4.0' + 0.23k/' × 7.5' + 0.49k/') / (29.5'/2)

S.P. = 1724 #/ft < 3000 #/ft

IWES 2-0186

INTERNATIONAL WASTE ENERGY SYSTEMS
2150 KIENLEN AVENUE
TELEPHONE (314) 389-7275
ST. LOUIS, MISSOURI 63121
TELEX 44-2438

PROJECT NO. 8613
SUBJECT FFPI
Bulk Solids
MADE BY
CHECKED BY
SHEET 2 OF 5
INDEX NO.
REV. NO.
DATE 1/6/89
DATE



SECTION B
5-009

CHECK BOTTOM SLAB

$w = 0.110^{k}/ft^3 \cdot 12.5' = 1.38^{k}/ft^2$

$0.15 \cdot 1.5' = 0.22$

$= 1.60^{k}/ft$

$M_{\text{2-WAY SLAB}} \sim 0.50 \cdot 1.60 \cdot \frac{16.0^2}{8} = 25.6'^{k}$

$A_{s\,reqd} = \frac{25.6'^{k}}{1.76 \cdot 18''} = 0.91^{\square''}$

IN FINAL DESIGN SLAB COULD BE DESIGNED AS CONT. SLAB IN ONE DIRECTION W/ SOME CONTINUITY IN OTHER.

IWES 2-0186

INTERNATIONAL WASTE ENERGY SYSTEMS

2150 KIENLEN AVENUE
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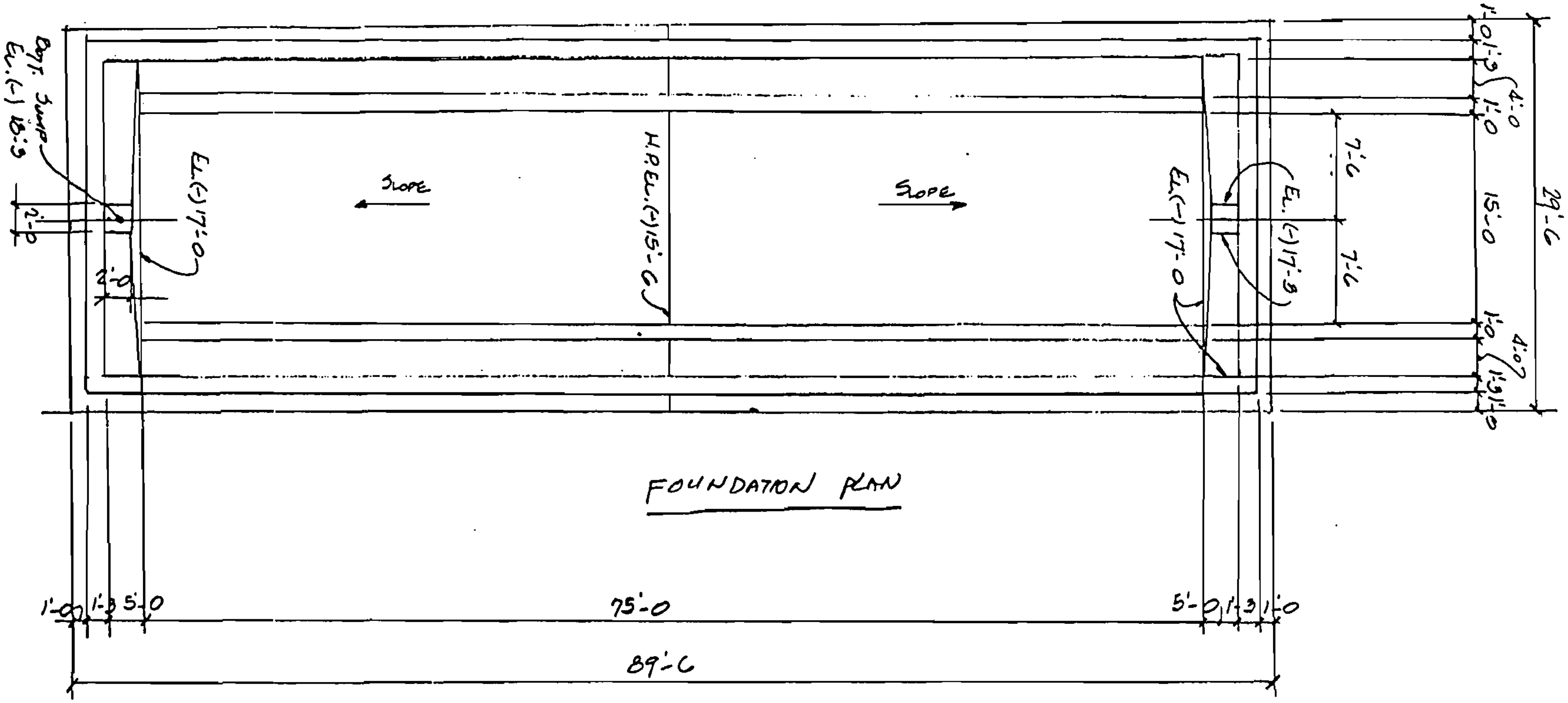
TELEX 44-2438

PROJECT NO. 8613
SUBJECT FFPI Bulk Sludge
MADE BY KL
CHECKED BY
SHEET 4 OF 5
INDEX NO.
REV. NO.
DATE 1/6/89
DATE



INTERNATIONAL WASTE ENERGY SYSTEMS
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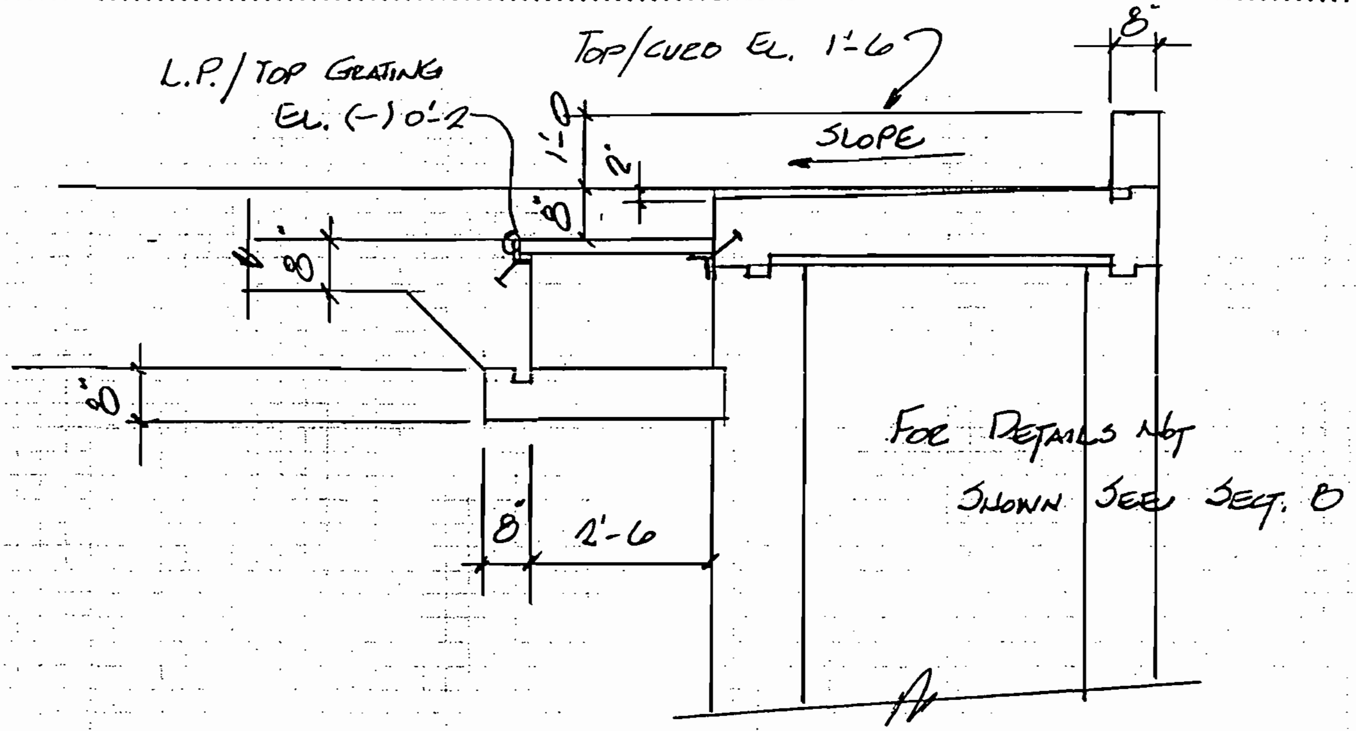
TELEX 44-2438

SHEET 5 OF 5
INDEX NO.
REV. NO.

PROJECT NO. 8813
SUBJECT FFPI
BULK SOLIDS UNLOADING
MADE BY KL DATE 1/6/09
CHECKED BY DATE



SECTION D / S-009

COPY OF NBS-PS-15-69

VOLUNTARY PRODUCT STANDARD FOR FRP TANKS

17 Appendix

The Following is a Reprint of

Voluntary Product Standard

PS 15-69

Custom Contact-Molded Reinforced-Polyester

Chemical Resistant Process Equipment

A Voluntary Standard

Developed by Producers,

Distributors, and Users with the

Cooperation of the

National Bureau of Standards

U.S. Department of Commerce

PRODUCT STANDARDS

Product Standards are published voluntary standards that establish (1) dimensional requirements for standard sizes and types of various products, (2) technical requirements for the product, and (3) methods of testing, grading, and marking these products. The objective is to define requirements for these products in accordance with the principal demands of the trade. *Product Standards* are published by the National Bureau of Standards of the U. S. Department of Commerce.

Development of a PRODUCT STANDARD

The Bureau's Office of Engineering Standards Services works closely with business firms, trade organizations, testing laboratories, and other appropriate groups to develop such standards. (A group interested in developing a *Product Standard* may submit a written request to the Office of Engineering Standards Services, National Bureau of Standards.) After determining that the desired standard would be technically feasible and in the public interest, a specific proposal is developed in consultation with interested trade groups and circulated for industry consideration and comment.

Subsequently, a Standard Review Committee is established to review the proposed standard for conformance with the Department of Commerce procedures. The committee includes qualified representatives of producers, distributors, and users or consumers of the product. When approved by the committee, copies of the recommended standard are distributed for consideration and acceptance. When the acceptances show general agreement by all segments of the industry, and when there is no substantive objection deemed valid by the National Bureau of Standards, the Bureau announces approval of the *Product Standard* and proceeds with its publication.

Use of a PRODUCT STANDARD

Product Standards are developed for the maximum use of industry by ensuring that producers, distributors, and users or consumers cooperate in the development of a voluntary *Product Standard*. The adoption and use of a *Product Standard* is *voluntary*. *Product Standards* are used most effectively in conjunction with legal instrumentalities such as building codes, purchase orders, and sales contracts. When a standard is made part of such a contract, compliance with the standard is enforceable by the buyer or the seller along with other provisions of the contract. There is *no* governmental regulation or control involved.

Purchasers may order products that comply with *Product Standards* and determine for themselves that their requirements are met. More often, manufacturers refer to the standards in sales catalogs, advertising, invoices, and labels on the product. Commercial inspection and testing programs are also employed for greater effectiveness together with grade labels, hallmarks, and certificates. Such assurance of compliance promotes confidence and understanding between buyers and sellers.

EFFECTIVE DATE

Having been passed through the regular procedures of the Office of Engineering Standards Services, National Bureau of Standards and approved by the acceptors hereinafter listed, this Product Standard is issued by the National Bureau of Standards, effective

November 15, 1969. (See section 6.)

Lewis M. Branscomb, *Director*

Nat. Bur. Stand. (U.S.), Prod. Stand. 15-69, 28 pages (June 1970)
CODEN: XNPSA

Voluntary Product Standard PS 15-69

Custom Contact-Molded Reinforced-Polyester Chemical-Resistant Process Equipment

(This voluntary standard, initiated by the Society of the Plastics Industry, Inc., has been developed under the *Procedures for the Development of Voluntary Product Standards*, published by the Department of Commerce. See section 7, *History of Project*, for further information.)

1. PURPOSE

1.1. The purpose of this Product Standard is to establish on a national basis the standard sizes and dimensions and significant quality requirements for commercially available glass-fiber-reinforced chemical-resistant process equipment for chemical service. The information contained in this Product Standard will be helpful to producers, distributors, and users and will promote understanding between buyers and sellers.

2. SCOPE

2.1. This Product Standard covers materials, construction and workmanship, physical properties, and methods of testing reinforced-polyester materials for process equipment and auxiliaries intended for use in aggressive chemical environments, including but not limited to pipe, ducts, and tanks. The Standard is based on the technology of fabrication by hand lay-up or contact pressure molding. Methods for identifying products which comply with the requirements of this Standard are included.

2.2. This Standard does not cover: (1) resins other than polyesters, (2) reinforcing materials other than glass fibers, (3) laminate constructions, or (4) filament wound fabrication methods. (The industry has initiated the development of additional standards to cover these items.)

3. REQUIREMENTS

3.1. General

3.1.1. Terminology—Unless otherwise indicated, the plastics terminology used in this Standard shall be in accordance with the definitions given in American Society for Testing and Materials (ASTM) Designation D883-69, *Standard Nomenclature Relating to Plastics*.[1]

3.1.2. General description—This Standard describes glass-fiber-reinforced process equipment for chemical service. Other materials may be used for reinforcement of the surface exposed to the chemical environment. This Standard is not intended to cover selection of the exact resin or reinforcement combination for use in specific chemical and structural conditions. For recommended chemical resistance test procedures, see the appendix.

3.2. Materials

3.2.1. Resin—The resin used shall be of a commercial grade and shall either be evaluated as a laminate by test (see appendix for a recommended test) or determined by previous service to be acceptable for the environment.

3.2.2. Fillers and pigments—The resins used shall not contain

[1] Later issues of the ASTM publications specified in this Product Standard may be used providing the requirements are applicable and consistent with the issue designated. Copies of ASTM publications are obtainable from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.

fillers except as required for viscosity control or fire retardance. Up to 5 percent by weight of thixotropic agent which will not interfere with visual inspection may be added to the resin for viscosity control. Resins may contain pigments and dyes by agreement between fabricator and purchaser, recognizing that such additions may interfere with visual inspection of laminate quality. Antimony compounds or other fire retardant agents may be added as required for improved fire resistance.

3.2.3. **Reinforcing material**—The reinforcing material shall be a commercial grade of glass fiber having a coupling agent which will provide a suitable bond between the glass reinforcement and the resin.

3.2.4. **Surfacing materials**—Unless otherwise agreed upon between fabricator and purchaser, material used as reinforcing on the surface exposed to chemical attack shall be a commercial grade chemical-resistant glass having a coupling agent.

Note: The use of other fibrous materials such as acrylic and polyester fibers and asbestos may affect the values obtained for the Barcol hardness of the surface.

3.3. **Laminate**—The laminate shall consist of an inner surface, an interior layer, and an exterior layer or laminate body. The compositions specified for the inner surface and interior layer are intended to achieve optimum chemical resistance.

3.3.1. **Inner surface**—The inner surface shall be free of cracks and crazing with a smooth finish and with an average of not over 2 pits per square foot, providing the pits are less than 1/8 inch in diameter and not over 1/32 inch deep and are covered with sufficient resin to avoid exposure of inner surface fabric. Some waviness is permissible as long as the surface is smooth and free of pits. Between 0.010 and 0.020 inches of reinforced resin-rich surface shall be provided.[2] This surface may be reinforced with glass surfacing mat, synthetic fibers, asbestos, or other material as usage requires.

3.3.2. **Interior layer**—A minimum of 0.100 inch of the laminate next to the inner surface shall be reinforced with not less than 20 percent nor more than 30 percent by weight of noncontinuous glass strands (see 4.3.1), e.g., having fiber lengths from 0.5 to 2.0 inches.

3.3.3. **Exterior layer**—The exterior layer or body of the laminate shall be of chemically resistant construction suitable for the service and providing the additional strength necessary to meet the tensile and flexural requirements. Where separate layers such as mat, cloth, or woven roving are used, all layers shall be lapped a minimum of 1 inch. Laps shall be staggered as much as possible. If woven roving or cloth is used, a layer of chopped-strand glass shall be placed as alternate layers. The exterior surface shall be relatively smooth with no exposed fibers or sharp projections. Hand work finish is acceptable, but enough resin shall be present to prevent fiber show.

3.3.3.1. When the outer surface is subject to a corrosive environment, the exterior surface shall consist of a chopped-strand glass over which shall be applied a resin-rich coating as described in 3.3.1. Other methods of surface protection may be used as agreed upon between buyer and seller.

3.3.4. **Cut edges**—All cut edges shall be coated with resin so that no glass fibers are exposed and all voids filled. Structural elements

[2] This resin-rich surface layer will usually contain less than 20 percent of reinforcing material. A specific limit is not included because of the impracticability of determining this value in the finished product.

having edges exposed to the chemical environment shall be made with chopped-strand glass reinforcement only.

3.3.5. **Joints**—Finished joints shall be built up in successive layers and be as strong as the pieces being joined and as crevice free as is commercially practicable. The width of the first layer shall be 2 inches minimum. Successive layers shall increase uniformly to provide the specified minimum total width of overlay which shall be centered on the joint. (See 3.3.1, 3.4.6.1, 3.5.6, and 3.6.5.) Crevices between jointed pieces shall be filled with resin or thixotropic resin paste, leaving a smooth inner surface. (See 3.3.1.) The interior of joints may also be sealed by covering with not less than 0.100 inch of reinforced resin-rich surface as described in 3.3.1 and 3.3.2.

3.3.6. **Wall thickness**—The minimum wall thickness shall be as specified in the tables under the appropriate sections, but in no case shall be less than 1/8 inch in the case of ducts and 3/16 inch in pipes and tanks regardless of operating conditions. Isolated small spots may be as thin as 80 percent of the minimum wall thickness, but in no case more than 1/8 inch below the specified wall thickness.

3.3.7. **Mechanical properties**—In order to establish proper wall thickness and other design characteristics, the minimum physical properties for any laminate shall be as shown in table 1 and 3.3.7.1. Laminates which do not meet the minimum values of table 1 are considered acceptable provided they are made to afford the same overall strength that would be obtained with a laminate meeting the specified thickness. For example, if the specified thickness for a laminate is 1/4 inch, reading from table 1 a minimum tensile strength of 12,000 psi is required. By multiplying thickness times minimum tensile strength a value of 3,000 pound breaking load for a 1-inch-wide specimen is obtained. A laminate having a tensile strength of 10,000 psi will, therefore, be acceptable for the 1/4-inch requirement if it has an actual thickness of at least 0.3 inch.

3.3.7.1. **Surface hardness**—The laminate shall have a Barcol hardness of at least 90 percent of the resin manufacturer's minimum specified hardness for the cured resin when tested in accordance with 4.3.5. This applies to both interior and exterior surfaces.

3.3.8. **Appearance**—The finished laminate shall be as free as commercially practicable from visual defects such as foreign inclusions, dry spots, air bubbles, pinholes, pimples, and delamination.

3.3.9. By agreement between buyer and seller, a representative laminate sample may be used for determination of acceptable surface finish and visual defects (see 3.3.1, 3.3.3, and 3.3.8).

TABLE 1. *Requirements for properties of reinforced-polyester laminates*

Property at 73.4 °F (23 °C)	Thickness (inches)			
	1/8 to 3/16	1/4	5/16	3/8 and up
	psi	*psi*	*psi*	*psi*
Ultimate tensile strength-minimum [1]	9,000	12,000	13,500	15,000
Flexural strength-minimum [2]	16,000	19,000	20,000	22,000
Flexural modulus of elasticity (tangent)-minimum [3]	700,000	800,000	900,000	1,000,000

[1] See 4.3.2.
[2] See 4.3.3.
[3] See 4.3.4.

3.4. Reinforced-polyester round and rectangular ducting[3]

3.4.1. Duct size and tolerances

3.4.1.1. Round ducting—The size of round ducting shall be determined by the inside diameter in inches. The standard sizes shall be 2, 3, 4, 6, 8, 10, 12, 14, 16, 18, 20, 24, 30, 36, 42, 48, 54, and 60 inches. Unless otherwise specified, the tolerance, including out-of-roundness, shall be ±1/16 inch for ducting up to and including 6-inch inside diameter, and ±1/8 inch or ±1 percent, whichever is greater, for ducting exceeding 6 inches in inside diameter.[4]

3.4.1.2. Rectangular ducting—The sizes of rectangular ducting shall be determined by the inside dimensions. There are no standard sizes for rectangular ducting. Unless otherwise specified, the tolerances on ordered sizes shall be ±3/16 inch for dimensions of 18 inches and under and ±1 percent for dimensions of over 18 inches.[4]

3.4.2. Lengths—Tolerances on overall lengths shall be ±1/4 inch unless arrangements are made to allow for field trimming.

3.4.3. Wall thickness—The minimum nominal thickness of round ducting shall be in accordance with table 2. For rectangular ducting, the minimum thickness shall be as specified in table 2, substituting the longer side for the diameter. See also 3.3.6.

3.4.4. Squareness of ends—Ends shall be square within ±1/8 inch for round ducting through 24-inch diameter and rectangular ducting through 72-inch perimeter; and ±3/16 inch for larger sizes of both round and rectangular ducting.

3.4.5. Fittings—Tolerances on angles shall be ±1° through 24 inches, ±7/8° for 30 inches, ±3/4° for 36 inches, ±5/8° for 42 inches, and ±1/2° for 48 inches and above. Wall thickness of fittings shall be at least that of ducting of the same size.

TABLE 2. *Reinforced-polyester round duct dimensions*[1]

I.D. *inches*	Wall thickness (Min.) *inches*	Allowable vacuum[2] *inches of water*	Allowable pressure[2] *inches of water*	Flange diameter (O.D.) *inches*	Flange thickness *inches*	Bolt circle diameter *inches*	Bolt hole diameter *inches*	No. of bolt holes
2	0.125	405	750	6-3/8	1/4	5	7/16	4
3	0.125	405	500	7-3/8	1/4	6	7/16	4
4	0.125	210	410	8-3/8	1/4	7	7/16	4
6	0.125	64	350	10-3/8	1/4	9	7/16	8
8	0.125	30	180	12-3/8	1/4	11	7/16	8
10	0.125	16	340	14-3/8	3/8	13	7/16	12
12	0.125	9	280	16-3/8	3/8	15	7/16	12
14	0.125	7	220	18-3/8	3/8	17	7/16	12
16	0.125	6	290	20-3/8	1/2	19	7/16	16
18	0.125	5	240	22-3/8	1/2	21	7/16	16
20	0.125	5	190	24-3/8	1/2	23	7/16	20
24	0.187	9	140	28-3/8	1/2	27	7/16	20
30	0.187	7	100	34-3/8	1/2	33	7/16	28
36	0.187	5	70	40-3/8	1/2	39	7/16	32
42	0.250	10	120	46-3/8	5/8	45	7/16	36
48	0.250	9	100	54-3/8	5/8	52	9/16	44
54	0.250	7	80	60-3/8	5/8	58	9/16	44
60	0.250	6	60	66-3/8	5/8	64	9/16	52

[1] 5 to 1 design factor of safety based on data in table 1. Also based on 10-foot lengths between stiffener rings for vacuum service.

[2] These ratings are suitable for use up to 180 °F (82.2 °C) in pressure service and ambient atmospheric temperatures on vacuum service. For ratings at higher temperatures consult the manufacturer.

[3] Rated at a minimum of 5-inch water vacuum and/or 50-inch water pressure. (See table 2.)

[4] See Footnote 9, page 14.

3.4.5.1. **Ells**—Standard ells shall have a centerline radius of one and one-half times the duct diameter.

3.4.5.2. **Laterals**—Standard laterals shall be 45°.

3.4.5.3. **Reducers, concentric or eccentric**—Length of standard reducers shall be five times the difference in diameters (D_1-D_2). Minimum wall thickness shall be that required for the larger diameter duct as given in table 2.

3.4.6. **Straight connections**

3.4.6.1. **Butt joint**—Strength of the butt joint shall be at least equal to that of the duct itself and shall be made in accordance with 3.3.5. Total minimum width of joint shall be 3 inches for 1/8 inch thickness, 4 inches for 3/16 inch thickness, and 6 inches for 1/4 inch thickness.

3.4.6.2. **Bell and spigot joint**—Straight duct shall be inserted into bell at least one-sixth of duct perimeter or 4 inches, whichever is less, and overwrapped in such a manner as to provide strength at least equal to that of the duct. The opening between the bell and spigot shall be sealed with thixotropic resin paste.

3.4.7. **Flanges**

3.4.7.1. **Flange dimensions**—Dimensions of reinforced plastic flanges for round ducts shall be in accordance with table 2. Flange thicknesses and width [(O.D.-I.D.)/2] of flange faces for rectangular ducts shall correspond to those for round ducts having the same diameter as the longer side of rectangular ducts.

3.4.7.2. **Flange attachment**—Duct wall at hub of flange shall be at least one and one-half times the normal thickness and taper to normal thickness over a distance of at least one flange width. Fillet radius shall be at least 3/8 inch at point where the hub meets the back of the flange.

3.4.7.3. **Face of flange**—Face of flange shall have no projections or depressions greater than 1/32 inch and shall be perpendicular to the centerline of the duct within 1/2°. A camber of 1/8 inch with respect to the centerline, measured at the O.D. of the flange, shall be allowable. The face of the flange shall have a chemical-resistant surface as described in 3.2.4 and 3.3.1.

3.4.7.4. **Drilling**—Standard flanges shall be supplied undrilled.

3.4.7.5. **Flange bolting**—The bolt holes shall straddle centerline unless otherwise specified. Unless otherwise specified, the number of bolt holes and diameters of bolt holes and bolt circles shall be in accordance with table 2. Rectangular flange width and bolt spacing shall be the same as that for diameters corresponding to the longer sides.

3.4.8. **Mechanical properties of ducts**

3.4.8.1. **Laminate**—The minimum mechanical properties shall be in accordance with table 1.

3.4.8.2. **Deflection**—Maximum deflection of a side on a rectangular duct shall not exceed 1 percent of the width of the side under operating conditions. Ribs or other special constructions shall be used if required to meet the deflection requirement.

3.4.9. **Stacks**—Special engineering consideration is required for structural design of stacks, and the manufacturers should be consulted.

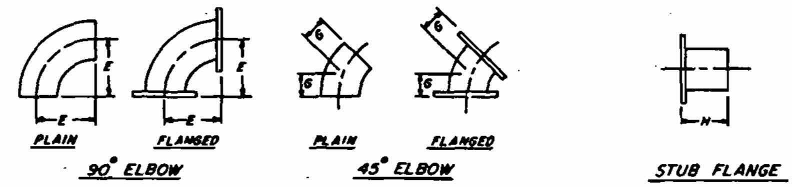
3.5. **Reinforced-polyester pipe** [5]

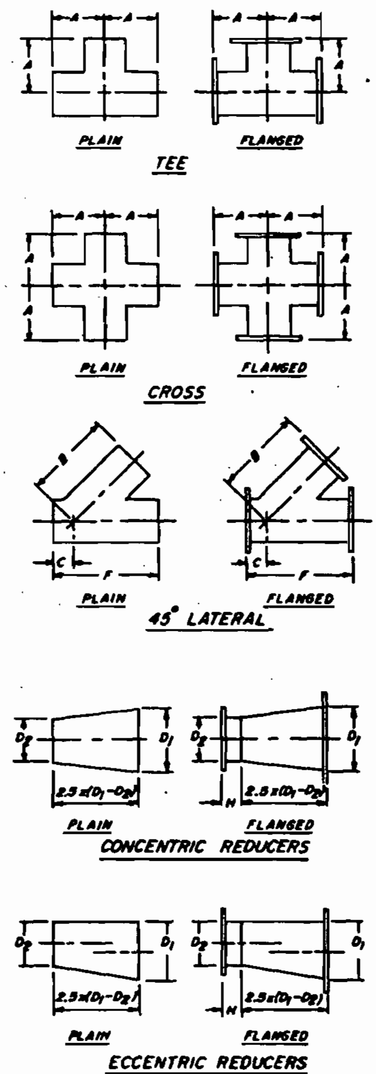
3.5.1. **Size**—The standard pipe size shall be the inside diameter in

[5] Rated from full vacuum to 150 psi (see table 3).

inches. Standard sizes are 2, 3, 4, 6, 8, 10, 12, 14, 16, 18, 20, 24, 30, 36, and 42 inches. The tolerance including out-of-roundness shall be ±1/16 inch for pipe up to and including 6-inch inside diameter, and ±1/8 inch or ±1 percent, whichever is greater, for pipe exceeding 6 inches in inside diameter. This measurement shall be made at the point of manufacture with the pipe in an unstrained vertical position.

3.5.2. **Length**—The length of each fabricated piece of pipe shall not vary more than ±1/8 inch from the ordered length unless arrangements are made to allow for trim in the field.





Dimensions (inches)

D	A	B	C	E	F	G	H
2	6	10	6	4	16	1 5/8	6
3	7	12	6	6	18	2 1/2	6
4	8	14	6	6	20	2 1/2	6
6	10	16	8	9	24	3 3/4	8
8	12	20	10	12	30	5	8
10	14	24	10	15	34	6 1/4	10
12	16	26	12	18	38	7 1/2	10
14	18	30	12	21	42	8 3/4	12
16	20	32	14	24	46	10	12
18	21	36	14	27	50	11 1/4	12
20	22	38	16	30	54	12 1/2	12
24	24	42	18	36	60	15	12
30	30	52	20	45	72	18 5/8	15
36	33	62	22	54	84	22 1/2	15
42	36	72	24	63	96	26	15

FIGURE 1. Dimensions of reinforced-polyester pipe fittings.

3.5.3. **Wall thickness**—The minimum wall thickness of the pipe shall be in accordance with table 3. See also 3.3.6.

3.5.4. **Squareness of ends**—All unflanged pipe shall be cut square with the axis of the pipe within ±1/8 inch up to and including 24-inch diameter and to within ±3/16 inch for all diameters above 24 inches.

3.5.5. **Fittings**—All fittings such as elbows, laterals, T's, and reducers shall be equal or superior in strength to the adjacent pipe section and shall have the same diameter as the adjacent pipe. The dimensions of fittings shall be as shown in figure 1. Tolerance on angles of fittings shall be ±1° through 24 inches in diameter and ±1/2° for 30-inch diameter and above. Where necessary, minimum overlay widths may be less than those specified in table 4, but the joint strength shall be at least equal to the strength of the adjacent pipe.

3.5.5.1. **Elbows**—Standard elbows shall have a centerline radius of one and one-half times the diameter. Standard elbows up to and including 24 inches shall be molded of one piece construction. Elbows of 30-inch diameter and larger may be of mitered construction using pipe for the mitered sections. The width of the overlay on the mitered joint may have to be less than the minimum specified in table 4 to avoid interference on the inner radius, but the joint strength must be at least equal to the strength of the adjacent pipe. Mitered elbows 45° or less will be one-miter, two section. Elbows above 45° through 90° shall have a minimum of two miters. Incorporation of straight pipe extensions on elbows is permissible.

3.5.5.2. **Reducers**—Reducers of either concentric or eccentric style will have a length as determined by the diameter of the large end of the reducer as indicated in figure 1.

3.5.6. **Butt joints**—This type of joint shall be considered the standard means of joining pipe sections and pipe to fittings. The procedure used in making the butt joint will be as outlined in 3.3.5. All pipe 20 inches in diameter and larger shall be overlaid both inside, when accessible, and outside. Pipe less than 20 inches in diameter shall be outside overlaid. The minimum width of the overlay shall relate to wall thickness and shall be of the dimensions indicated in table 4. Inside overlaps may be made to seal the joint if necessary, but shall not be considered in meeting the strength requirement specified in 3.3.5.

3.5.7. **Flanges**—The use of flanges shall normally be kept to a minimum with the butt joint being used as the standard means of joining pipe sections. All flanges shall be of the minimum thickness given in table 5 and accompanying illustration. The construction of flanges is the same as that for laminates. (See 3.3.)

3.5.7.1. **Flange attachment**—The minimum flange shear surrace shall be four times the flange thickness indicated in table 5. The thickness of the flange hub reinforcement measured at the top of the fillet radius shall be at least one-half the flange thickness and shall be tapered uniformly the length of the hub reinforcement. The fillet radius, where the back of the flange meets the hub, shall be 3/8 inch minimum.

3.5.7.2. **Flange face**—The flange face shall be perpendicular to the axis of the pipe within 1/2° and shall be flat to ±1/32 inch up to and including 18-inch diameter and ±1/16 inch for larger diameters. The face of the flange shall have a chemical resistant surface as described in 3.2.4 and 3.3.1.

TABLE 3. *Reinforced-polyester pipe wall thickness*

Pipe size	Minimum pipe wall thicknesses[1] at pressure ratings:					
	25 psi	50 psi	75 psi	100 psi	125 psi	150 psi
inches	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*
2	3/16	3/16	3/16	3/16	3/16	3/16
3	3/16	3/16	3/16	3/16	1/4	1/4
4	3/16	3/16	3/16	1/4	1/4	1/4
6	3/16	3/16	1/4	1/4	5/16	3/8
8	3/16	1/4	1/4	5/16	3/8	7/16
10	3/16	1/4	5/16	3/8	7/16	1/2
12	3/16	1/4	3/8	7/16	1/2	5/8
14	1/4	5/16	3/8	1/2	5/8	3/4
16	1/4	5/16	7/16	9/16	11/16	
18	1/4	3/8	1/2	5/8	3/4	
20	1/4	3/8	1/2	11/16		
24	1/4	7/16	5/8	13/16		
30	5/16	1/2	3/4			
36	3/8	5/8				
42	3/8	3/4				

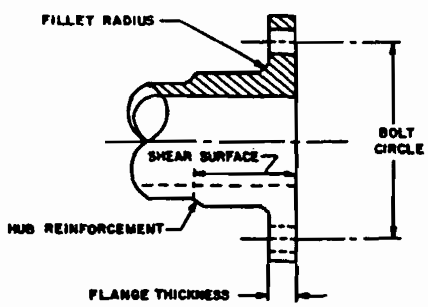
[1] The specified wall thicknesses are based upon a 10 to 1 safety factor for the tensile strength listed in table 1. These ratings are suitable for use up to 180 °F (82.2 °C); for ratings at higher temperatures, consult the manufacturer. For vacuum service see 3.5.9.

TABLE 4. *Minimum total widths of overlays for reinforced-polyester butt joints*

Pipe wall thickness, inches ----------	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4
Minimum total width of overlay, inches ----------	3	4	5	6	7	8	9	10	11	12

3.5.7.3. **Other flange designs**—Other flanges agreed upon between the fabricator and the user are acceptable provided that they produce a tight joint at twice the pressures established for standard joints.

3.5.8. **Mechanical properties of pipe**—The minimum mechanical properties of pipe shall be in accordance with table 1.



3.5.9. **Vacuum service**—In sizes 2 through 18 inches, reinforced-polyester pipe and fittings have an internal pressure rating of 125 psi. Flanges having a rating of 25 psi are suitable for full vacuum service. Special engineering consideration is required for larger pipe sizes and for operation at temperatures above ambient atmospheric temperature.

3.5.10. **Recommended installation practice**

3.5.10.1. Pipe hangers and spacing—Hangers shall be band type hangers contacting a minimum of 180° of the pipe surface. The maximum pipe hanger spacing shall be in accordance with table 6.

3.5.10.2. Underground installation—Special consideration must be given to installing pipe underground. It is recommended that the manufacturer be consulted for installation procedures.

3.5.10.3. Expansion—Since the expansion rate of this plastic pipe is several times that of steel, proper consideration should be given to any pipe installation to accommodate the overall linear expansion.

TABLE 5. *Minimum flange thickness for reinforced-polyester pressure pipe* [1 2 3]

Pipe size	Minimum flange thickness at design pressures:					
	25 psi	50 psi	75 psi	100 psi	125 psi	150 psi
inches	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*
2	1/2	1/2	1/2	9/16	5/8	11/16
3	1/2	1/2	5/8	11/16	3/4	13/16
4	1/2	9/16	11/16	13/16	7/8	15/16
6	1/2	5/8	3/4	7/8	1	1-1/16
8	9/16	3/4	7/8	1	1-1/8	1-1/4
10	11/16	7/8	1-1/16	1-3/16	1-5/16	1-7/16
12	3/4	1	1-1/4	1-7/16	1-5/8	1-3/4
14	13/16	1-1/16	1-5/16	1-1/2	1-3/4	1-7/8
16	7/8	1-3/16	1-7/16	1-5/8	1-7/8	
18	15/16	1-1/4	1-1/2	1-3/4	2	
20	1	1-5/16	1-5/8	1-7/8		
24	1-1/8	1-1/2	1-7/8			
30	1-3/8	1-7/8				
36	1-3/4					
42	2					

[1] Based on flat-faced flanges with full-face soft gaskets.
[2] Flange dimensions (except thickness) and bolting correspond to the following standards:
2-inch through 24-inch sizes: USA Std. B16.5 for 150 lb steel flanges.
30-inch through 42-inch sizes: USA Std. B16.1 for 125 lb C.I. flanges.
[3] This table is based on a safety factor of 8 to 1 and a flexural strength of 20,000 psi. This latter value is slightly under the minimum flexural strength for laminates of 3/8 inch and up (see table 1), due to the manufacturing technique.

3.5.10.4. Bolts, nuts, and washers—Bolts, nuts, and washers shall be furnished by the customer. Metal washers shall be used under all nut and bolt heads. All nuts, bolts, and washers shall be of materials suitable for use in the exterior environment.

3.5.10.5. Gaskets—Gaskets shall be furnished by the customer. Recommended gasketing materials shall be a minimum of 1/8 inch in thickness with a suitable chemical resistance to the service environment. Gaskets should have a Shore A or Shore A2 Hardness of 40 to 70.

3.6. Reinforced-polyester tanks (stationary nonpressure vessels)

3.6.1. Cylindrical flat-bottom vertical tanks

3.6.1.1. Sizes—Standard tank sizes are 2, 2-1/2, 3, 3-1/2, 4, 4-1/2, 5, 5-1/2, 6, 7, 8, 9, 10, 11, and 12 feet in inside diameter.

3.6.1.2. Dimensions and tolerances—The tank diameter shall be measured internally. Tolerance on the inside diameter, including out-of-roundness, shall be ±1 percent. Measurement shall be taken with tank in vertical position. Taper, if any, shall be increasing and shall be added to the nominal diameter. Taper shall not exceed 1/2° per side. Tolerance on overall height shall be ±1/2 percent, but shall not exceed ±1/2 inch. The radius at bottom to wall shall be a minimum of 1-1/2 inches.

3.6.1.3. **Wall thickness**—The minimum wall thickness shall be in accordance with table 7. See also 3.3.6.

3.6.2. **Horizontal cylindrical tanks**

3.6.2.1. **Sizes, dimensions, and tolerances**—These shall be the same as for vertical cylindrical tanks (see 3.6.1.). Standard end closures shall be standard convexed, domed heads with a maximum radius of curvature equal to the tank diameter. The knuckle radius shall be a minimum of 1-1/2 inches.[6]

3.6.2.2. **Support cradle**—Two support cradles shall be provided. The cradles shall be at least 6 inches wide, supporting at least 120° of the tank circumference. Wear plates (reinforced areas), 12 inches wide, covering 180° of the support surface shall be provided when required. Laminate construction and minimum thickness shall be as agreed upon between fabricator and purchaser. Tanks longer than 24 feet require special design and support consideration.

3.6.2.3. **Wall thickness**—The minimum wall thickness shall be in accordance with table 8. See also 3.3.6.

3.6.3. **Rectangular tanks**

3.6.3.1. **Sizes**—There are no standard sizes for rectangular tanks.

3.6.3.2. **Dimensions and tolerances**—The length and width shall be measured internally. Tolerances on nominal dimensions of length and width shall be ±1/4 inch or ±1/4 percent, whichever is greater. Overall height tolerance shall be ±3/8 inch. Taper is increasing and should be added to the nominal dimensions. Taper should not exceed 1/2° per side.

3.6.3.3. **Side wall**—Deflection shall not exceed 1/2 percent of span at any location when tested by filling with water.

3.6.3.4. **Wall thickness**—Since the design of rectangular tanks is considerably more complex than that of cylindrical tanks, no simple chart of wall thickness can be given. However, the minimum wall should be similar to that for cylindrical tanks with consideration

TABLE 6. *Maximum spacing of pipe hangers for reinforced-polyester pressure pipe*[1]

Pipe I.D.	Maximum pipe hanger spacing at pressure ratings:					
	25 psi	50 psi	75 psi	100 psi	125 psi	150 psi
inches	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*
2	6.0	6.0	6.0	6.0	6.0	6.0
3	6.5	6.5	6.5	6.5	8.0	8.0
4	7.0	7.0	7.0	8.5	8.5	8.5
6	8.0	8.0	9.0	9.0	10.0	10.5
8	8.5	10.0	10.0	10.5	11.0	11.5
10	9.5	10.5	11.5	12.0	12.5	13.0
12	10.0	11.5	12.5	13.0	13.5	14.0
14	11.5	12.5	13.0	14.0	15.0	15.5
16	12.0	13.0	14.0	15.5	16.5	17.0
18	12.5	14.5	15.0	16.0	16.5	17.5
20	12.5	15.0	15.5	17.0	18.0	18.5
24	8.5	15.0	17.0	18.5	19.0	
30	9.5	17.5	19.5	21.0		
36	10.5	19.5	21.0			
42	8.0	21.0	22.5			

[1] The above table is based on uninsulated pipe containing liquids having a specific gravity of 1.3 and at a maximum temperature of 180 °F. For services at temperatures above 180 °F (82.2 °C), consult the manufacturer relative to hanger spacing.

[6] Larger knuckle radii are commonly used, such as for ASME orispherical heads.

Table 7. ***Minimum wall and bottom thickness of vertical tanks relative to diameter and distance from top*** [1]

Distance from top	Minimum wall and bottom thickness for tanks of diameter:														
feet	2 ft	2½ ft	3 ft	3½ ft	4 ft	4½ ft	5 ft	5½ ft	6 ft	7 ft	8 ft	9 ft	10 ft	11 ft	12 ft
2	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16
4	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16
6	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	1/4	1/4	1/4
8	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4	5/16
10	3/16	3/16	3/16	3/16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4	5/16	5/16	5/16
12	3/16	3/16	3/16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4	5/16	5/16	5/16	3/8
14	3/16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4	5/16	5/16	5/16	5/16	3/8	3/8
16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4	1/4	5/16	5/16	3/8	3/8	3/8	7/16
18	3/16	3/16	3/16	1/4	1/4	1/4	1/4	5/16	5/16	5/16	3/8	3/8	3/8	7/16	1/2
20	3/16	3/16	1/4	1/4	1/4	1/4	5/16	5/16	5/16	3/8	3/8	3/8	7/16	1/2	1/2
22	3/16	1/4	1/4	1/4	1/4	5/16	5/16	5/16	5/16	3/8	3/8	7/16	1/2	1/2	9/16
24	3/16	1/4	1/4	1/4	1/4	5/16	5/16	5/16	3/8	3/8	7/16	1/2	1/2	9/16	5/8

[1] Based on a safety factor of 10 to 1 using mechanical property data in table 1 and a liquid specific gravity of 1.2. For tanks intended for service above 180 °F (82.2 °C) consideration in design should be given to the physical properties of the material at the operating temperature. Tanks with physical loadings, such as agitation, should be given special design consideration.

TABLE 8. *Minimum wall and head thicknesses for reinforced-polyester horizontal cylindrical tanks using two support cradles*[1]

Tank length	Minimum wall and head thickness for tanks of diameter[2]							
	2 ft	3 ft	4 ft	5 ft[3]	6 ft[4]	8 ft[5]	10 ft[6]	12 ft[7]
ft	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*
8	3/16	3/16	1/4	1/4	5/16	5/16	7/16	9/16
10	3/16	1/4	1/4	5/16	5/16	3/8	7/16	9/16
12	3/16	1/4	1/4	5/16	5/16	7/16	1/2	5/8
14	1/4	1/4	5/16	5/16	3/8	1/2	9/16	3/4
16	1/4	5/16	5/16	3/8	3/8	9/16	11/16	13/16
18	1/4	5/16	3/8	7/16	7/16	5/8	13/16	15/16
20	5/16	5/16	3/8	7/16	1/2	11/16	7/8	1-1/16
22	5/16	3/8	3/8	1/2	9/16	3/4	15/16	1-3/16
24	5/16	3/8	7/16	1/2	5/8	13/16	1	1-1/4

[1] Based on 5 to 1 safety factor using the mechanical property data in table 1, a liquid specific gravity of 1.2, and support cradles located 1/12 of tank length from each end. For tanks intended for service above 180 °F (82.2 °C) consideration in design should be given to the physical properties of the material at the operating temperature. Tanks with physical loadings (such as agitation), other support designs, stiffening rings, or for use in situations requiring higher safety factors should be given special design consideration. In the use of more than two support cradles, maintenance of uniform support of the tank at all points of support is essential.

[2] For intermediate standard tank inside diameters given in 3.6.1.1, the minimum wall and head thickness shall be that given in this table for the next higher diameter.

[3] Wear plates required for 8-foot tank length.

[4] Wear plates required for 8-, 10-, and 12-foot tank lengths.

[5] Wear plates required for tanks 8 to 18 feet long, inclusive.

[6] Wear plates required for tanks 8 to 20 feet long, inclusive.

[7] Wear plates required for all tank lengths.

given to the height of the tank relative to loadings and the largest span relative to deflection. External ribs shall be used to prevent side wall deflection from exceeding the tolerance in 3.6.3.3. See also 3.3.6.

3.6.4. Mechanical property requirements for tanks—The minimum mechanical properties shall be as specified in table 1.

3.6.5. Shell joints—Where tanks are manufactured in sections and joined by use of a laminate bond, the joint shall be glass-fiber-reinforced resin at least the thickness of the heaviest section being joined. The reinforcement shall extend on each side of the joint a sufficient distance to make the joint at least as strong as the tank wall and shall be not less than the minimum joint widths specified in table 9. The reinforcement shall be applied both inside and out with the inner reinforcement considered as a corrosion resistant barrier only and not structural material. The inner reinforcement shall consist of a minimum of 3 ounces of glass per square foot, followed by 0.010 inch to 0.020 inch of surfacing material (see 3.3.5).

3.6.6. Flanges

3.6.6.1. Flanged nozzles—Flanges for liquid inlets and outlets shall meet the same requirements as for pipe (see 3.5.7 to 3.5.7.3 inclusive). At assembly there shall be a minimum dimension of 4 inches from the flange face to the tank. Where angular loadings are anticipated, the flange nozzle shall be supported by a minimum of three gussets or by other suitable means of structural support.

3.6.6.2. Assembly of flanges—Standard orientation will have bolt holes straddling principal centerline of vessel unless otherwise specified.

3.6.6.3. Tolerances—Tolerances on flange construction shall be the same as for pipe flanges (see 3.5.7 and table 5). Location of nozzles on the vessel shall be held to ±1/8 inch.

3.6.7. Recommended installation practice

3.6.7.1. Flat bottom tanks should be supported on a flat surface or on properly-spaced dunnage. It is recommended, where possible, that a flat surface, preferably a reasonably soft surface (confined sand or cinder-filled pad, plywood-surfaced concrete or a concrete grout) be used. Where full bottom support is not possible, special bottom design is required.

3.6.7.2. Closed tanks should have a properly sized vent.

TABLE 9. ***Minimum total widths of overlays for reinforced-polyester tank shell joints***

Tank wall thickness, inches	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4
Minimum of outside overlay width, inches	4	4	5	6	7	8	9	10	11	12
Minimum of inside overlay width, inches	4	4	5	5	6	6	6	6	6	6

4. INSPECTION AND TEST PROCEDURES

4.1. **Specimens**—Tests shall be made on specimens cut from waste areas when possible; otherwise, the specimens shall be cut from flat laminates prepared in the same construction and by the same techniques as the process equipment. In all cases, the average value of the indicated number of specimens shall be used to determine conformance with the detailed requirements.

4.2. **Conditioning**—The test specimens shall be conditioned in accordance with Procedure A of ASTM Designation D618-61, *Standard Methods of Conditioning Plastics and Electrical Insulating Materials for Testing.*[7]

4.3. **Tests**

4.3.1. **Glass content**—The glass content shall be determined in accordance with ASTM Designation D2584-67T, *Tentative Method of Test for Ignition Loss of Cured Reinforced Resins*,[8] except that the specimens tested shall be approximately 1 square inch in area, and low temperature preignition prior to placement in muffle furnace is recommended. The average for five specimens shall be considered to be the glass content.

4.3.2. **Tensile strength**—Tensile strength shall be determined in accordance with ASTM Designation D638-68, *Standard Method of Test for Tensile Properties of Plastics*,[7] except that the specimens shall be the actual thickness of the fabricated article and the width of the reduced section shall be 1 inch. Other dimensions of specimens shall be as designated by the ASTM standard for Type I specimens for materials over 1/2 inch to 1 inch inclusive. Specimens shall not be machined on the surface. Tensile strength shall be the average of five specimens tested at 0.20 to 0.25 in/min speed.

4.3.3. **Flexural strength**—Flexural strength shall be determined in accordance with Procedure A and table 1 of ASTM Designation D790-66, *Standard Method of Test for Flexural Properties of Plastics*,[7] except that the specimens shall be the actual thickness of the fabricated article and the width shall be 1 inch. Other dimen-

[7] See footnote 1, page 1.

sions of specimens shall be as designated by the ASTM standard. Specimens shall not be machined on the surface. Tests shall be made with the resin-rich side in compression using five specimens.

4.3.4. **Flexural modulus**—The tangent modulus of elasticity in flexure shall be determined by ASTM Method D790-66 (see 4.3.3).

4.3.5. **Hardness**—The hardness shall be determined in accordance with ASTM Designation D2583-67, *Standard Method of Test for Indentation Hardness of Plastics by Means of a Barcol Impressor.*[8] Calibration of the Barcol instrument shall be verified by comparing with blank specimens having known readings of 85 to 87 and 42 to 46. Ten readings on the clean resin-rich surface shall be made. After eliminating the two high and two low readings, the average of the remainder shall be the reported hardness reading.

4.3.6. **Additional tests**—Recommended test methods for the fur ther testing of reinforced-polyester laminates are given in the appendix. These test methods are included as recommendations and are not to be considered as requirements from the standpoint of determining compliance with the Standard.

5. IDENTIFICATION

5.1. **Labels and literature**—In order that purchasers may identify products complying with all requirements of this Voluntary Product Standard, producers choosing to produce such products in conformance with this voluntary Standard may include a statement in conjunction with their name and address on labels, invoices, sales literature, and the like. The following statement is suggested when sufficient space is available:[9]

> This product conforms to all of the requirements established in Product Standard PS 15-69, developed cooperatively with the industry and published by the National Bureau of Standards under the Voluntary Product Standards procedures of the U.S. Department of Commerce. Full responsibility for the conformance of this product with the standard is assumed by (name and address of producer or distributor).

5.1.1. The following abbreviated statement is suggested when available space on labels is insufficient for the full statement[9]:

Conforms to PS 15-69 (name and address of producer or distributor).

6. EFFECTIVE DATE

6.1. The effective date of a Voluntary Product Standard is the date upon which reference to the Standard may be made by producers, distributors, users and consumers, and other interested parties. Compliance by producers with the requirements of a Product Standard may not actually occur until some time after the effective date. Products shall not be labeled or otherwise described as conforming to a Product Standard until such time as all applicable requirements established in the Standard are met. The effective date of this Standard is November 15, 1969.

7. HISTORY

7.1. In June 1965, The Society of the Plastics Industry, Inc., requested the assistance of the National Bureau of Standards in the

[8] See footnote 1, page 1.

[9] All tolerances exceeding those stated in 3.4.1.1 and 3.4.1.2 shall be identified as exceptions in statements representing compliance with this Standard.

development of a standard for custom contact-molded reinforced-polyester chemical-resistant process equipment. In February 1966, a proposed standard was circulated to representative producers, distributors, users, and other interested organizations for comment. All comments and suggestions received from this circulation were carefully considered and the proposed standard was adjusted where practicable.

With the approval and recommendation of its Standard Review Committee, the recommended standard was circulated in January 1968, to determine its acceptability to the industry. The comments received from this circulation were considered by the Standard Review Committee, and in accordance with their recommendations a new draft was prepared. This draft was circulated for acceptance in October 1968.

The response to the October 1968 circulation indicated a consensus of acceptability, as defined under the *Procedures for the Development of Voluntary Product Standards*, existed within the industry with regard to the standard. In August and September 1969, the Standard Review Committee and the acceptors were balloted concerning the deletion of the "hallmark" from the standard. The response to this balloting indicated a consensus of acceptance had again been achieved, and on October 17, 1969, the standard, designated PS 15-69, *Custom Contact-Molded Reinforced-Polyester Chemical-Resistant Process Equipment*, was approved for publication by the National Bureau of Standards to be effective November 15, 1969.

***Technical Standards Coordinator*:**
D. R. Stevenson, Product Standards Section, Office of Engineering Standards Services, National Bureau of Standards, Washington, D. C. 20234.

8. STANDING COMMITTEE

8.1. The following individuals comprise the membership of the Standing Committee which is to review all revisions proposed to keep this Standard abreast of progress. Comments concerning the Standard and suggestions for revision may be addressed to any member of the committee or to the Office of Engineering Standards Services, National Bureau of Standards, U.S. Department of Commerce, which acts as secretary for the committee.

Representing Producers

William E. Smith, The Ceilcote Company, Inc., 140 Sheldon Road, Berea, Ohio 44017 (Chairman)

J. A. Jellesen, Amercoat Corporation, 111 Colgate Avenue, Buffalo, New York 14220

Fred W. Arndt, Heil Process Equipment Corporation, 12901 Elmwood Avenue, Cleveland, Ohio 44111

Richard H. Brackett, Corite-Reynolds Corporation, 455 Jarvis Avenue, Des Plaines, Illinois 60018

W. P. Jenks, Owens-Corning Fiberglas Corporation, Toledo, Ohio 43601

C. B. Sias, PPG Industries, Inc., P.O. Box 127, Springdale, Pennsylvania 15144

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Walter A. Szymanski, Durez Plastics Division, Hooker Chemical Corporation, Walck Road, North Tonawanda, New York 14121

Representing Users

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Otto Fenner, Monsanto Company, 800 N. Lindbergh Boulevard, St. Louis, Missouri 63166

John H. Davis, Eastman Chemical Products, Inc., Kingsport, Tennessee, 37666

W. F. Carn, Diamond Alkali Company, 300 Union Commerce Building, Cleveland, Ohio 44114

Ronald R. Skabo, Wyandotte Chemicals Corporation, Wyandotte, Michigan 48193

R. W. LaValley, Corrosion Controllers, Inc., 345 Second Street, Washougal, Washington 98671

Representing General Interests

Charles L. Condit, The Society of the Plastics Industry, Inc., 250 Park Avenue, New York, New York 10017

Charles H. Angell, 500 South Avenue, Glencoe, Illinois 60022

9. ACCEPTORS

9.1. The manufacturers, distributors, users, and others listed below have individually indicated in writing their acceptance of this Product Standard prior to its publication. The acceptors have indicated their intention to use the Standard as far as practicable but reserve the right to depart from it when necessary. The list is published to show the extent of recorded public support for the Standard.

ASSOCIATIONS
(General Support)

Manufacturing Chemists Association, Washington, D.C.
Society of the Plastics Industry, Inc., New York, New York
Society of the Plastics Industry of Canada, Don Mills, Ontario, Canada

PRODUCERS

Amercoat Corporation, Brea, California
An-Cor Industrial Plastics, Inc., North Tonawanda, New York
Atlantic Bridge Company, LTD, Plastics Division, Mahone Bay, N. S., Canada
Atlas Plastics, Inc., Buffalo, New York
Beetle Plastics Division ,Crompton & Knowles Corporation, Fall River, Massachusetts
Bittner Industries, Inc., Mobile, Alabama
Carolina Fiberglass Products Company, Wilson, North Carolina
Ceilcote, The, Company, Berea, Ohio
Century Fiberglass, Inc., Anaheim, California
Chemical Construction Corporation, New York, New York
Corite Reynolds Corporation, Des Plaines, Illinois
Duriron, The, Company, Inc., Enzinger Division, Angola, New York
Ershig's, Inc., Bellingham, Washington
Fibraco Manufacturing Company, Inc., Clear Lake, Iowa
Glastronics Corporation, New Bedford, Massachusetts
Hasbrouck Plastics, Inc., Hamburg, New York
Hays Manufacturing Company, Erie, Pennsylvania
Heil Process Equipment Corporation, Cleveland, Ohio
Heil Process Equipment Southeast Corporation, Bartow, Florida
Hood Manufacturing, Inc., Wilmington, California
Jones & Hunt, Inc., Orwigsburg, Pennsylvania
Justin Enterprises, Inc., Fairfield, Ohio
Kenner Boat Company, Knoxville, Arkansas
Kenway Corporation, Palermo, Maine
Leopold Reinforced Plastics Company, Zelienople, Pennsylvania
Lunn Laminates, Inc., Wyandanch, New York
Metal-Cladding, Inc., North Tonawanda, New York
Pennwalt Corporation, Philadelphia, Pennsylvania
Polytex Manufacturers, Inc., Houston, Texas
Precisioneering Limited, Scarborough, Ontario, Canada
Protective Plastic Company, Bedford, Ohio
Protective Plastics, Don Mills, Ontario, Canada
Red Ewald Fiber Glass, Karnes City, Texas
Resin Fab Corporation, Belding, Michigan
Rubber & Plastic Applicators, Inc., Mobile, Alabama
Schori Process Corporation, Port Washington, New York
Shell Chemical Company, New York, New York
Simons, H. A. (International) LTD, Vancouver, B. C., Canada
Smith-Inland, A. O., Inc., Little Rock, Arkansas
Technical Service Corporation, St. Louis, Missouri
Warminster Fiberglass Company, Southampton, Pennsylvania

DISTRIBUTORS, USERS, AND GENERAL INTEREST

Allegheny Plastics, Inc., Coraopolis, Pennsylvania
American Air Filter—Fiber Glass Group, Louisville, Kentucky
American Cyanamid Company, Bound Brook, New Jersey
American Cyanamid Company, Wallingford, Connecticut
American Standards Testing Bureau, Inc., New York, New York
Angell, Charles H., Consultant, Glencoe, Illinois
Atlas Chemical Industries, Inc., Wilmington, Delaware
Braun, C. F., & Company, Alhambra, California
California Testing Laboratories, Inc., Los Angeles, California
Chemacryl Plastics, LTD, Toronto, Ontario, Canada
Corrosion Controllers, Inc., Washougal, Washington
Diamond Shamrock Chemical Company, Cleveland, Ohio
Durez Division, N. Tonawanda, New York
Eastman Chemical Products, Inc., Kingsport, Tennessee
FMC Corporation, Front Royal, Virginia
Freeman Chemical Corporation, Port Washington, Wisconsin
General Foods Corporation, White Plains, New York
Glidden-Durkee, Strongsville, Ohio
Imperial Chemical Industries of Australia & New Zealand, LTD.
Kahn, P. A., & Company, Newton, Massachusetts
Main, Chas. T., Inc., Boston, Massachusetts
Monsanto Company, St. Louis, Missouri
Omaha Testing Laboratories, Inc. Omaha, Nebraska
Phillips Petroleum Company, Bartlesville, Oklahoma
PPG Industries, Shelby, North Carolina
PPG Industries, Inc., Springdale, Pennsylvania
Proctor & Gamble Company, Cincinnati, Ohio
Reinforced Plastics Testing Laboratory, Lindenhurst, New York
Rohm and Haas Company, Bristol, Pennsylvania
Ryerson, Joseph T., and Son, Inc., Chicago, Illinois
Sandwell International, Inc., Portland, Oregon
Singmaster & Breyer, New York, New York
Star Hi Enterprises, Inc., Melrose Park, Illinois
Stauffer Chemical Company, Dobbs Ferry, New York
Titanium Metals Corporation of America, Henderson, Nevada
Twining, The, Laboratories, Inc., Fresno, California
Union-Camp Corporation, Savannah, Georgia

FEDERAL GOVERNMENT

General Services Administration, Washington, D.C.
Interior, U.S. Department of, Washington, D.C.

10. APPENDIX

Supplemental Information

A.1. Chemical resistance

A1.1. Test—ASTM Designation C581-68, *Standard Method of Test for Chemical Resistance of Thermosetting Resins Used in Glass Fiber Reinforced Structures*[1] is recommended for the evaluation of the chemical resistance of materials to be used in reinforced-polyester chemical-resistant process equipment. The reinforcing materials prescribed in the test laminate are only for the purpose of establishing a uniform basis for comparison. They may not necessarily represent the preferred materials for the particular environment. This procedure may be adapted to test or evaluate components, composition or fabrication variations, and production samples. For information on the basis for selection of the standard test laminate, see Appendix A1 of ASTM C581-68.

A1.1.1. The 10-mil surfacing mat referred to in paragraph 5.1.2.1 of C581-68 shall be made of chemical resistant glass (Type C or equal).

A1.1.2. The standard test laminate shall be cured at room temperature for 16 hours. Further cure shall be given at room or higher temperature, if necessary, to produce a Barcol hardness equal to the resin manufacturer's minimum specified hardness for the cured resin.

[1] This method is based on a test procedure developed by the Reinforced-Plastics Corrosion-Resistant Structures Subcommittee of The Society of the Plastics Industry, Inc. See footnote 1, page 1.

A1.2. Temperature—Tests may be conducted at any or all of these temperatures: 23 °C, 50 °C, 70 °C, 100 °C (±2 °C); reflux temperature; required service temperature.

A1.3. Reagents—The following reagents are suggested for use in obtaining general comparative chemical resistance data. The test solutions shall not be agitated, i.e., the exposures shall be under static conditions.

1. 25% Sulfuric acid
2. 15% Hydrochloric acid
3. 5% Nitric acid
4. 25% Acetic acid
5. 15% Phosphoric acid
6. 5% Sodium hydroxide
7. 10% Sodium carbonate
8. Saturated sodium chloride
9. 95% Ethanol
10. 5-1/4% Sodium hypochlorite*
11. 5% Aluminum potassium sulfate
12. Ethyl acetate
13. Methylethyl ketone
14. Monochlorbenzene
15. Perchlorethylene
16. n-Heptane
17. Kerosine
18. Toluene
19. 5% Hydrogen peroxide*
20. Distilled water*

* Replaced every 48 hours with fresh solution

A1.4. Time—The properties specified in A1.5 shall be determined for specimens immersed in the test solutions for 30 days, 90 days, 180 days, and 1 year for one set of control specimens immediately following the curing period; and for another set after aging in air at the test temperature for the total test period.

A1.5. Properties—Thickness, Barcol hardness, flexural strength and modulus, and appearance shall be determined at each time interval. Appearance observations shall include any surface changes, color changes, obvious softening or hardening, crazing, delamination, exposure of fibers, or other effects indicative of complete degradation or potential failure. Calculation of percentage change in a property shall be based on the property value obtained immediately following the curing period.

A1.6. Report—Data shall be reported in tabular form for all parameters tested. The composition (including resin), accelerators, catalysts, and reinforcements, and the fabricating and curing conditions of the laminate tested shall be adequately described.

A2. Fire retardancy [2]—The fire retardancy may be determined in accordance with ASTM Designation E84-68 *Standard Method of Test for Surface Burning Characteristics of Building Materials.*[3]

A3. Compressive strength (edgewise)—The compressive strength may be determined in accordance with ASTM Designation D695-63T, *Tentative Method of Test for Compressive Properties of Rigid Plastics.*[3]

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[2] Work is in progress to develop test procedures and specification requirements for applications requiring fire resistance.
[3] See footnote 1, page 1.

APPENDIX D-3

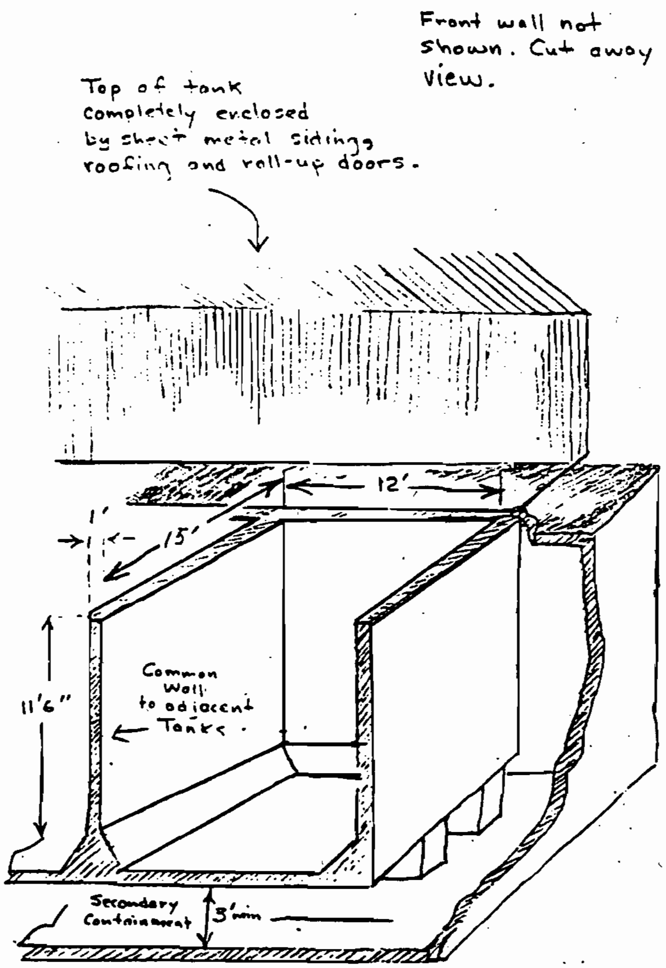
Replace in entirety

IWES	Shredded Material Tank DATA SHEET	SPEC. NO.
	PROJECT FFPI - 8813	SHEET 1 OF 1
		PROJ. NO.: 8813

1	Equipment No.:	B-01	
2	Equipment Name:	Shredded Material Tank	
3	Equipment Service:		
4			
5			
6			
7			
8			
9			
10	**PERFORMANCE**		
11	Operating Pressure	psig	Atmospheric
12	Operating Temperature	deg. F	Ambient
13	Density	lb/cu.ft.	120
14	Contents Lethal		(NO) YES
15	Design Pressure	psig	Atmospheric
16	Design Temperature	deg. F	30 - 99
17	Volume (WORKING)	cu.ft.	675
18			
19	Hydrostatic Test	psig	NO
20	Shell Thickness	in.	12
21	Base Thickness	in.	12
22			
23			
24	**CONSTRUCTION**		
25	Insulation	in.	NO
26	Fireproofing		(NO) YES
27	Sandblasting		(NO) YES
28	Paint/Sealer		Concrete Sealer
29	Wind Load	mph	NA
30	Seismic Zone		1
31	Design Code		ACI-318
32	**MATERIALS OF CONSTRUCTION**		
33	Walls	Reinforced Concrete	
34	Base	Reinforced Concrete	
35			
36			
37	**NOZZLE SCHEDULE**		

	Description	Mark	Size	Rating	Type
38	Description	Mark	Size	Rating	Type
39	NONE	A			
40	↓	B			
41	↓	C			
42	↓	D			
43	↓				
44	↓				

SKETCH



Note: All dimensions are approximate

REMARKS

REVISION NO.	C-2				
PREPARED BY/DATE	JAD 8/1/90				
CHECKED BY/DATE	RWG 8/27/90				
APPROVED BY/DATE	[illegible] 9/2?/90				

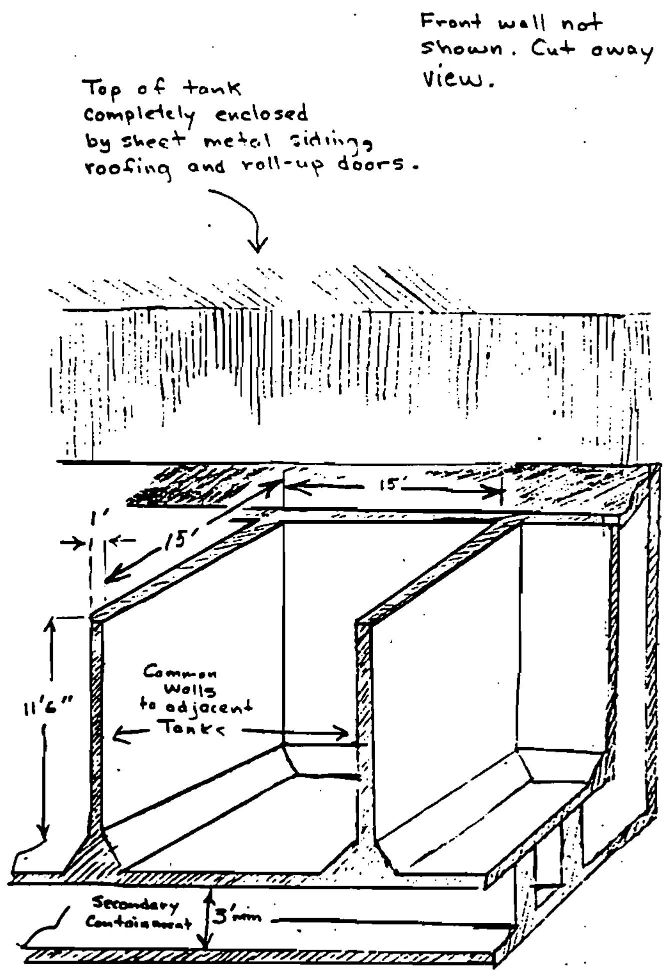
IWES-001 SHEET 1 OF 1

IWES	Bulk Solids Receiving Tank DATA SHEET	SPEC. NO.
	PROJECT FFPI - 8813	SHEET 1 OF 1
		PROJ. NO.: 8813

1	Equipment No.:	B-02 03, 04		
2	Equipment Name:	Bulk Solids Receiving Tank		
3	Equipment Service:			
4				
5				
6				
7				
8				
9				
10	**PERFORMANCE**			
11	Operating Pressure	psig	Atmospheric	
12	Operating Temperature	deg. F	Ambient	
13	Density	lb/cu.ft.	120	
14	Contents Lethal		(NO) YES	
15	Design Pressure	psig	Atmospheric	
16	Design Temperature	deg. F	30 - 99	
17	Volume (WORKING)	cu.ft.	1350	
18				
19	Hydrostatic Test	psig	NO	
20	Shell Thickness	in.	12	
21	Base Thickness	in.	12	
22				
23				
24	**CONSTRUCTION**			
25	Insulation	in.	NO	
26	Fireproofing		(NO) YES	
27	Sandblasting		(NO) YES	
28	Paint/Sealer		Concrete Sealer	
29	Wind Load	mph	NA	
30	Seismic Zone		1	
31	Design Code		ACI-318	
32	**MATERIALS OF CONSTRUCTION**			
33	Walls	Reinforced Concrete		
34	Base	Reinforced Concrete		
35				
36				
37	**NOZZLE SCHEDULE**			

	Description	Mark	Size	Rating	Type
38	Description	Mark	Size	Rating	Type
39	NONE	A			
40	↓	B			
41		C			
42		D			
43					
44					

SKETCH



Note: All dimensions are approximate

REMARKS

REVISION NO.	C-2				
PREPARED BY/DATE	JAO 8/1/90				
CHECKED BY/DATE	RWA 8/27/90				
APPROVED BY/DATE	[illegible] 9/2/90				

IWES-001 SHEET 1 OF 1

IWES

Bulk Solids Mixed Feed Tank

DATA SHEET

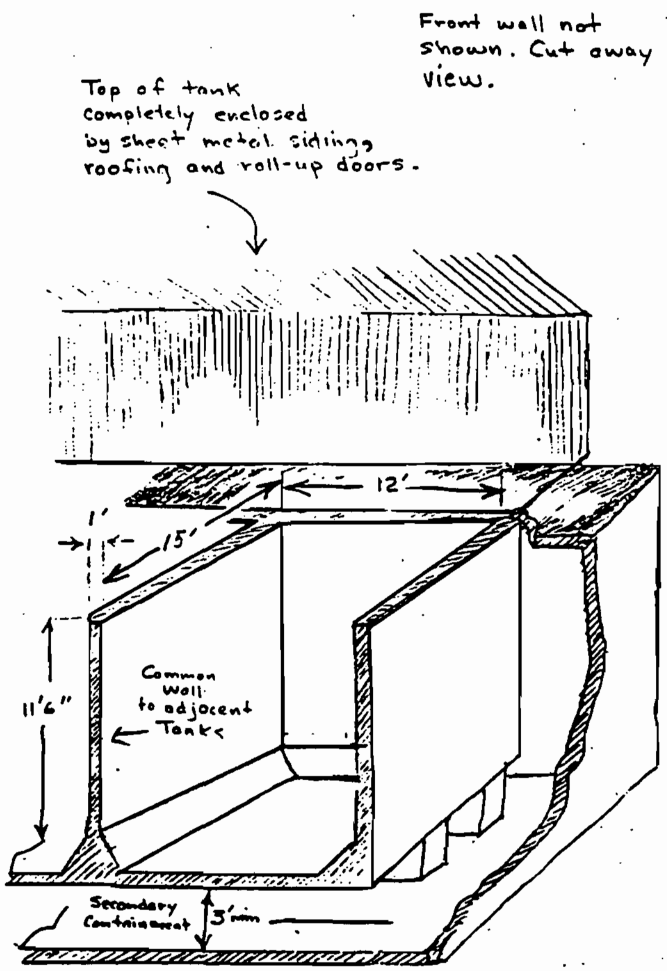
SPEC. NO.	
SHEET	1 OF 1
PROJ. NO.:	8813

PROJECT FFPI - 8813

1	Equipment No.:	B-05	
2	Equipment Name:	Bulk Solids Mixed Feed Tank	
3	Equipment Service:		
4			
5			
6			
7			
8			
9			
10	**PERFORMANCE**		
11	Operating Pressure	psig	Atmospheric
12	Operating Temperature	deg. F	Ambient
13	Density	lb/cu.ft.	120
14	Contents Lethal		(NO) YES
15	Design Pressure	psig	Atmospheric
16	Design Temperature	deg. F	30 - 99
17	Volume (WORKING)	cu.ft.	675
18			
19	Hydrostatic Test	psig	NO
20	Shell Thickness	in.	12
21	Base Thickness	in.	12
22			
23			
24	**CONSTRUCTION**		
25	Insulation	in.	NO
26	Fireproofing		(NO) YES
27	Sandblasting		(NO) YES
28	Paint/Sealer		Concrete Sealer
29	Wind Load	mph	NA
30	Seismic Zone		1
31	Design Code		ACI-318
32	**MATERIALS OF CONSTRUCTION**		
33	Walls	Reinforced Concrete	
34	Base	Reinforced Concrete	
35			
36			
37	**NOZZLE SCHEDULE**		

	Description	Mark	Size	Rating	Type
39	NONE	A			
40	↓	B			
41		C			
42		D			
43					
44					

SKETCH



Note: All dimensions are approximate

REMARKS

REVISION NO.	C-2				
PREPARED BY/DATE	JAO 8/1/90				
CHECKED BY/DATE	FWC 9/27/90				
APPROVED BY/DATE	PCK 9/27/90				

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SPECIFICATION NO. ______
EQUIPMENT NO. T-01

DATE: 09/05/89
REV: C-2
BY: J.A.O.
CHK'D BY: LDC, JS

PROJECT NAME: FFPI
EQUIPMENT NAME/APPLICATION: DRIED SOLIDS STORAGE SILO
IWES PROJECT No. 8813

DESIGN DATA

Operating Pressure	psig	Atmospheric	
Operating Temperature	°F	350°	
~~Liquid~~ Specific Gravity (SOLIDS)		0.8	
Contents Lethal		~~Yes~~	No
Design Pressure	psig	N/A	
Design Temperature	°F	400°	
Volume/Capacity, ft³		5000 ft³ (37,405 gal)	
L/D ratio		2.5	
Hydrostatic Test	psig		
Shell / Head Corr. Allow.	in.	1/8	1/8
Shell / Head Joint Eff.	%	85	85
Code: API-650		Stamp ~~Yes~~	No
Radiograph: SPOT		Stress Relieve:	
Type Supports: 8 LEGS			
Insulation:			
Fireproofing:			
Sandblast:		Paint:	
Manhole ☒ Hinged	☐ Davited	☐ Other:	
Platform Clips:	Ladder Clips: YES	Insul. Rings:	
Pipe Supports:			
Wind Load: 100 mph (SEC. I)		Seismic: ZONE 1 (ANSI)	
Wt. Empty	lb.	Wt. Full of Water	lb.

MATERIALS

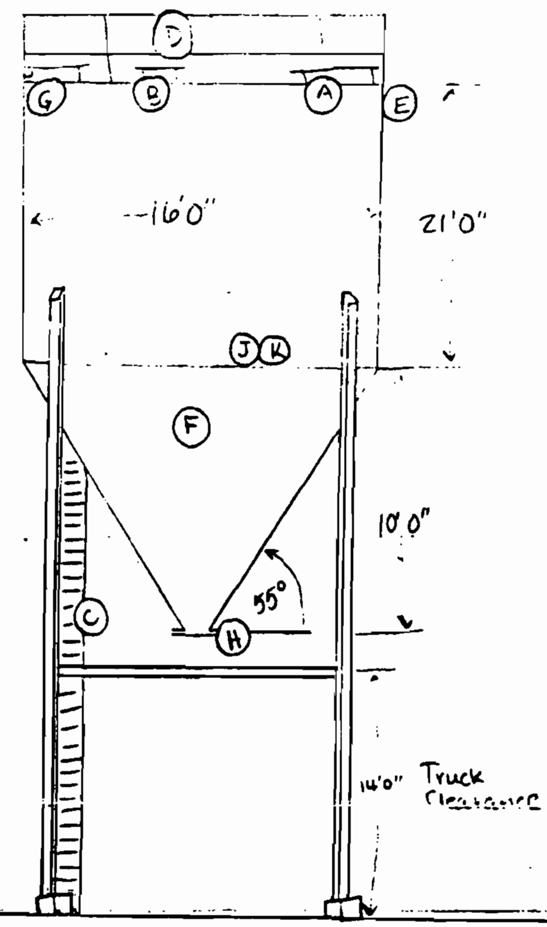
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	CS	A-285, GR. C
~~Heads~~ CONE	3/4 in.	CS	A-285, GR. C
Lining	in.		
	in.		
	in.		
Nozzle Necks	CS		A-36
Flanges	CS		
Coupling	↓		↓
M.H. Cover	↓		↓
Supports	↓		↓
Bolts/Studs	↓		↓
Nuts	↓		↓
Gaskets			

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
MANWAY	A	1	24"			
VENT/BAG HOUSE	B	1	24"			
LADDER	C	1	18"			
RAILING	D	1	36"			
LSHH	E	1	2"			
LUG SUPPORT PLATE	F	2	4"			
FILL	G	1	24"			
DISCHARGE	H	1	24			
TEMP	J	1	2"			
SPARE	K	1	2"			
	L					
	M					
	N					
	P					
	Q					
	R					

*Nozzle to be Plugged or Blinded

TANK SKETCH



- Design nozzle (H) to support rotary air lock at discharge nozzle
- Only two of eight legs shown for purpose of clarity.

Note: All dimensions are approximate

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VERTICAL TANK DATA SHEET

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SPECIFICATION NO. ____________

EQUIPMENT NO. T-02

DATE: 09/05/89
REV: C-2
BY: J.A.O.
CHK'D BY: LDC, JS

PROJECT NAME: EFPI
EQUIPMENT NAME/APPLICATION: DRIED SOLIDS RECYCLE SILO
IWES PROJECT No. 8813

DESIGN DATA

Operating Pressure	psig	ATMOSPHERIC	
Operating Temperature	°F	350°	
~~Liquid~~ Specific Gravity (SOLIDS)		0.8	
Contents Lethal		~~Yes~~	No
Design Pressure	psig	N/A	
Design Temperature	°F		
VOLUME		1350 cu ft	
Hydrostatic Test	psig		
Shell / Head Corr. Allow.	in.	1/8	1/8
Shell / Head Joint Eff.	%	85	85
Code: API-650		Stamp ~~Yes~~	No
Radiograph: SPOT		Stress Relieve:	
Type Supports: 8 LEGS			
Insulation:			
Fireproofing:			
Sandblast:		Paint:	
Manhole ☒ Hinged	☐ Davited	☐ Other:	
Platform Clips:	Ladder Clips: YES	Insul. Rings:	
Pipe Supports:			
Wind Load: 100 MPH (SEC ?)		Seismic: ZONE (ANSI)	
Wt. Empty	lb.	Wt. Full of Water	lb.

MATERIALS

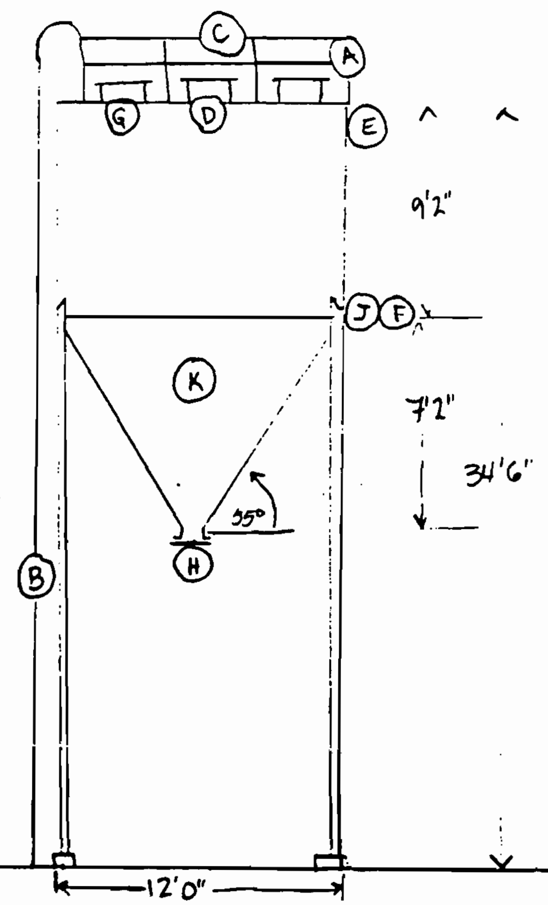
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	CS	A-285, GR.C
~~Heads~~ CONE	1/2 in.	CS	A-285, GR.C
Lining	in.	—	
	in.		
	in.		
Nozzle Necks	CS		A-36
Flanges	↓		↓
Coupling			
M.H. Cover			
Supports			
Bolts/Studs			
Nuts	↓		↓
Gaskets			

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
MANWAY	A	1	24"			
LADDER	B	1	18"			
RAILING	C		36"			
BAGHOUSE/VENT	D		24"			
LSHH	E		2"			
SPARE	F		2"			
FILL	G		24"			
DISCHARGE	H		24"			
TEMP	J		2"			
STRIKER PLATE	K		4'-4"			
	L					
	M					
	N					
	P					
	Q					
	R					

*Nozzle to be Plugged or Blinded

TANK SKETCH



- Design nozzle (H) To support rotary airlock at discharge nozzle
- Only two of eight legs shown for purpose of clarity.

Note: All dimensions are approximate

IWES 15-0186

International Waste Energy Systems

VERTICAL TANK DATA SHEET

SHEET 1 OF 1
DATE: 08/12/90
REV: C-2
BY: JAO
CHK'D BY: KWG

SPECIFICATION NO. ______
EQUIPMENT NO. T-04

PROJECT NAME: FFPI
EQUIPMENT NAME/APPLICATION: Dried Solids Recycle Suspension Tank
IWES PROJECT No. 8813

DESIGN DATA

Operating Pressure		Atmospheric	
Operating Temperature °F		20 TO 120	
Liquid Specific Gravity		1.3	
Contents Lethal		~~Yes~~	No
Design Pressure		Atmospheric	
Design Temperature °F		150	
CAPACITY		3,000 GALL.	
Hydrostatic Test psig		NO	
Shell / Heads Corr. Allow. in.		N/A	N/A
Shell / Heads Joint Eff. %		N/A	N/A
Code: NBS-PS 15-69		Stamp ~~Yes~~	No
Radiograph: NO		Stress Relieve:	
Type Supports: 4 legs			
Insulation: NO			
Fireproofing: NO			
Sandblast: NO		Paint: NO	
Manhole ☐ Hinged	☐ Davited	☒ Other:	
Platform Clips:	Ladder Clips:	Insul. Rings:	
Pipe Supports:			
Wind Load: 100 mph (SBCCI)		Seismic: Zone	(ANSI)
W[illegible]pty lb.		Wt. Full of Water lb.	

MATERIALS

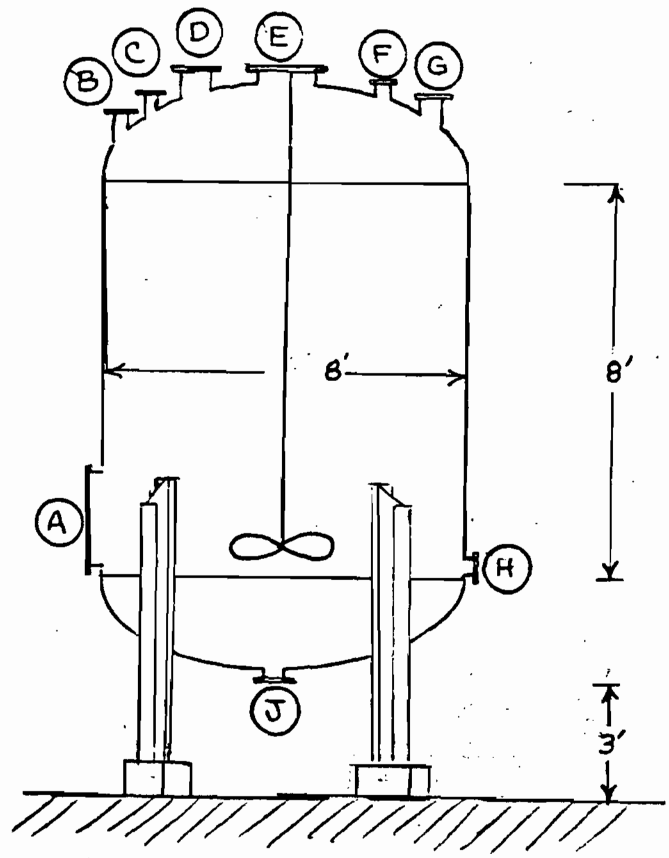
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	FRP	ASTM D3299
Heads	3/8 in.	FRP	ASTM D3299
Lining	in.		
	in.		
	in.		
Nozzle Necks	FRP		
Flanges	FRP		
Coupling			
M.H. Cover	FRP		
Supports	CS		
Bolts/Studs			
Nuts			
Gaskets			

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
Manway	A	1	24"	150#		FLG
Inlet	B	1	2"	↓		↓
PSV	C	1	3"			
Inlet	D	1	8"			
Agitator	E	1	8"			
Level Transmitter	F	1	2"			
Inlet	G	1	3"			
Outlet	H	1	4"			
Drain	J	1	2"	↓		↓
	K					
	L					
	M					
	N					
	P					
	Q					
	R					

*Nozzle to be Plugged or Blinded

TANK SKETCH



Only two of four legs shown.

Note: All dimensions are approximate

IWES 15-0188

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SPECIFICATION NO. ______
EQUIPMENT NO. T-07

DATE: 09/05/89
REV: C-2
BY: LDC
CHK'D BY: PB, JS RWA 8/22/90

PRO[illegible]T NAME: FFPI
EQUIPMENT NAME/APPLICATION: ALKALINE/CYANIDE WASTE DISSOLVING TANK-INORGANIC WASTE
WES PROJECT No. 8813

DESIGN DATA

Operating Pressure	psig	ATMOSPHERIC	
Operating Temperature	°F	32° to 125°	
Liquid Specific Gravity		~~1.25~~	
Contents Lethal		~~Yes~~	No
Design Pressure	psig	N/A	
Design Temperature	°F	180	
DESIGN pH		7-14	
CAPACITY		5000 gal.	
Hydrostatic Test	psig		
Shell / Hopper Corr. Allow.	in.	1/8"	1/8"
Shell / Hopper Joint Eff.	%	85	85
Code: API-650		Stamp ~~Yes~~	No
Radiograph: SPOT		Stress Relieve:	
Type Supports: 8 LEGS			
Insulation:			
Fireproofing:			
Sandblast:		Paint:	
Manhole ☐ Hinged	☐ Davited	☐ Other: SEE NOTE	
Platform Clips:	Ladder Clips:	Insul. Rings:	
Pipe Supports:			
Wind Load: 100 MPH (SEC I)		Seismic: ZONE I (ANSI)	
Wt. E[illegible]	lb.	Wt. Full of Water	lb.

MATERIALS

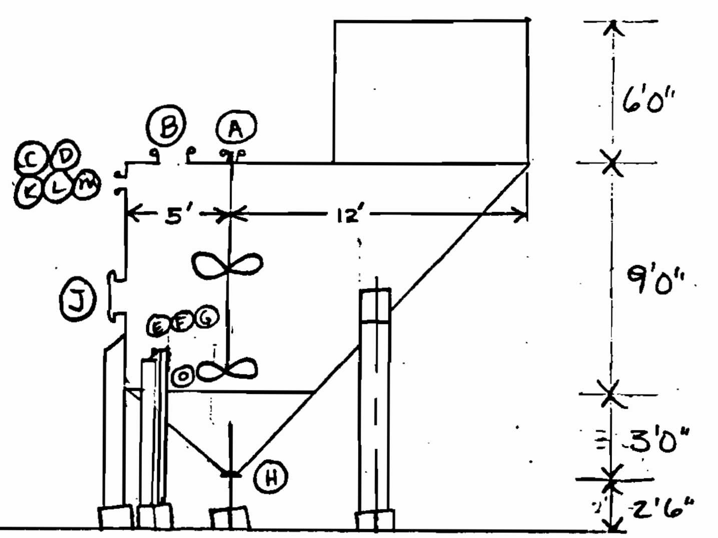
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	CS	A-285, Gr. C
Heads (HOPPER)	5/16 in.	CS	A-285, Gr. C
Lining	in.	see note	
	in.		
	in.		
Nozzle Necks		CS	
Flanges		CS	
Coupling			
M.H. Cover			
Supports	CS		A36
Bolts/Studs			
Nuts			
Gaskets			

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
AGITATOR	A	1		150#	RF	FLG
MANWAY	B	1	24"			
VENT	C	1	6"			
LSHH	D	1	2"			
TEMPERATURE	E	1	2"			
SPARE	F	1	4"			
SUCTION	G	1	4"			
SUCTION	H	1	4"			
MANWAY	J	1	24"			
WATER	K	1	2"			
S[illegible]n	L	1	2"			
S[illegible]E	M	1	4"	↓	↓	↓
	N	1				
	P					
	Q					
	R					

Nozzle to be Plugged or Blinded

TANK SKETCH



NOTE: ALL INTERNAL SURFACES TO BE LINED. LINING TO BE SELECTED DURING DETAILED DESIGN
TOP: MANHOLE HINGED
SIDE MANHOLE DAVITED

Only Four of eight legs shown for purpose of clarity

International Waste Energy Systems

VERTICAL TANK DATA SHEET

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SPECIFICATION NO.
EQUIPMENT NO. T-08

DATE: 09/05/89
REV: C-2
BY: LDC
CHK'D BY: PB, JS RWG 8/27/90

PROJECT NAME: FFPI
EQUIPMENT NAME/APPLICATION: ACIDIC/CHROMATE WASTE DISSOLVING TANK - INORGANIC WASTE
WES PROJECT No. 8813

DESIGN DATA

Operating Pressure	psig	ATMOSPHERIC
Operating Temperature	°F	32° to 125°
Liquid Specific Gravity		1.25
Contents Lethal		~~Yes~~ No
Design Pressure	psig	N/A
Design Temperature	°F	180
Design pH		0-7
CAPACITY		5000 gal
Hydrostatic Test	psig	
Shell / Hopper Corr. Allow.	in.	1/8" / 1/8"
Shell / Hopper Joint Eff.	%	85 / 85
Code: API-650		Stamp ~~Yes~~ No
Radiograph: SPOT		Stress Relieve:
Type Supports: 8 LEGS		
Insulation:		
Fireproofing:		
Sandblast:		Paint:
Manhole ☐ Hinged ☐ Davited ☐ Other: SEE NOTE		
Platform Clips:	Ladder Clips:	Insul. Rings:
Pipe Supports:		
Wind Load: 100 MPH (SBCCI)		Seismic: ZONE I (ANSI)
Wt. Empty	lb.	Wt. Full of Water lb.

MATERIALS

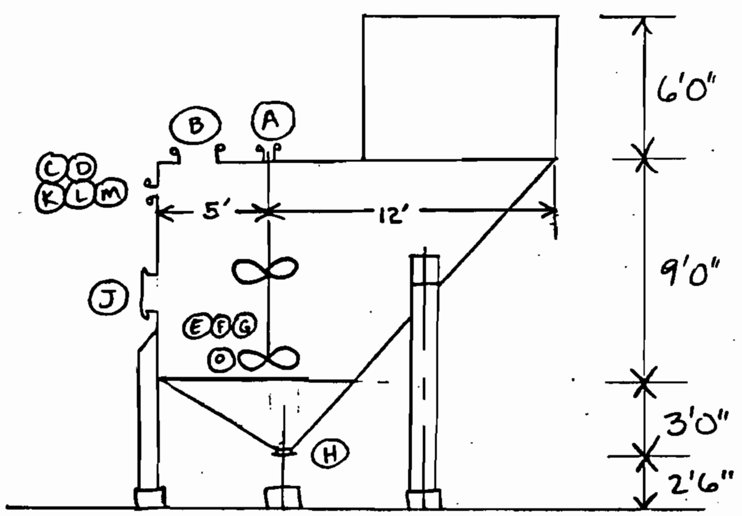
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	CS	A-285, Gr. C
~~Heads~~ HOPPER	5/16 in.	CS	A-285, Gr. C
Lining	in.	see note	
	in.		
	in.		
Nozzle Necks		CS	
Flanges		CS	
Coupling			
M.H. Cover	CS		A36
Supports			
Bolts/Studs			
Nuts			
Gaskets			

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
AGITATOR	A	1		150#	RF	FLG
MANWAY	B	1	24"			
VENT	C	1	6"			
LSHH	D	1	2"			
TEMPERATURE	E	1	2"			
SPARE	F	1	4"			
SUCTION	G	1	4"			
SUCTION	H	1	4"			
MANWAY	J	1	24"			
WATER	K	1	2"			
[illegible]m	L	1	2"			
[illegible]E	M	1	4"			
	N	1				
	P					
	Q					
	R					

Nozzle to be Plugged or Blinded

TANK SKETCH



NOTE: ALL INTERNAL SURFACES TO BE LINED. LINING TO BE SELECTED DURING DETAILED DESIGN.
TOP MANHOLE HINGED
SIDE MANHOLE DAVITED

Only three of eight legs shown for purpose of clarity.

Note: All dimensions are approximate

WES 15-0186

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SPECIFICATION NO. ____________

EQUIPMENT NO. T-09

DATE: 09/05/89
REV: C-2
BY: LDC
CHK'D BY: JAD, JS

PROJECT NAME: FFPI

EQUIPMENT NAME/APPLICATION: DRUMMED PUMPABLE WASTE RECEIVER-ORGANIC WASTE

WES PROJECT No. 8813

DESIGN DATA

Operating Pressure	psig	+4" WC to +18" WC	
Operating Temperature	°F	20 to 120	
Liquid Specific Gravity		1.70	
Contents Lethal		~~Yes~~	No
Design Pressure	psig	-10" WC to 5 PSIG	
Design Temperature	°F	150°	
CAPACITY		4000 gal	
HEATING		EXTERNAL STEAM COILS	
Hydrostatic Test	psig	15	
Shell / Heads Corr. Allow.	in.	1/8	1/8
Shell / Heads Joint Eff.	%	85	85
Code: API 620		Stamp ~~Yes~~	No
Radiograph: SPOT		Stress Relieve:	
Type Supports: 4 LEGS			
Insulation: YES			
Fireproofing:			
Sandblast:		Paint:	
Manhole ☐ Hinged	☒ Davited	☐ Other:	
Platform Clips:	Ladder Clips:	Insul. Rings:	
Pipe Supports:			
Wind Load: 100 MPH (SBCCI)		Seismic: ZONE I (ANSI)	
Wt. Empty	lb.	Wt. Full of Water	lb.

MATERIALS

Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	CS	A-285, Gr. C
Heads	5/16 in.	CS	A-285, Gr. C
Lining	in.		
	in.		
	in.		
Nozzle Necks		CS	
Flanges		CS	
Coupling			
M.H. Cover		CS	
Supports		CS	A 36
Bolts/Studs		CS	
Nuts		CS	
Gaskets	TEFLON		

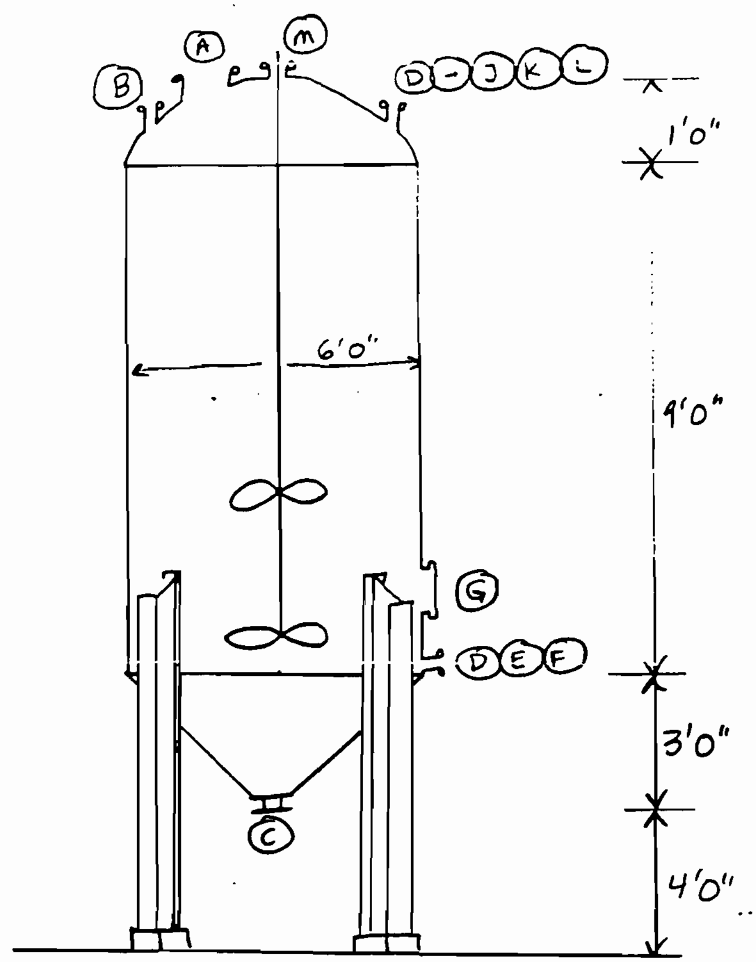
NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
MANWAY/PSV	A	1	24"	150#	RF	FLG
FILL	B	1	2"			
PUMPSUCTION	C	1	4"			
LEVEL TRANSM	D	2	4"			
TEMPERATURE	E	1	2"			
SPARE	F	1	4"			
MANWAY	G	1	24"			
PRESS TRANS	H	1	2"			
VENT	J	2	3"			
[illegible]	K	1	4"			
SPARE	L	1	4"			
AGITATOR	M	1		↓	↓	↓
	N					
	P					
	Q					
	R					

Nozzle to be Plugged or Blinded

WES 15-0186

TANK SKETCH



Only two of four legs shown for purpose of clarity

Note: All dimensions are approximate

International Waste Energy Systems

VERTICAL TANK DATA SHEET

BEST AVAILABLE COPY

SPECIFICATION NO. ______

EQUIPMENT NO. T-10, 11, 12, 13, 14, 15

SHEET ___ OF ___

DATE: 09/05/89

REV: C-2

BY: LDC

CHK'D BY: JAD., JS RWL 8/27/90

PRO[illegible]CT NAME: FFPI

EQUIPMENT NAME/APPLICATION: ORGANIC RECEIVING/HOLDING TANKS

WES PROJECT No. 8813

DESIGN DATA

Operating Pressure	psig	+4" WC to +18" WC	
Operating Temperature	°F	70° to 120°	
Liquid Specific Gravity		1.25	
Contents Lethal		~~Yes~~	No
Design Pressure	psig	-10" WC to +5 PSIG	
Design Temperature	°F	150°	
CAPACITY		19,500 GAL	
Hydrostatic Test	psig	15	
Shell / Heads Corr. Allow.	in.	1/8	1/8
Shell / Heads Joint Eff.	%	85	85
Code: API 620		Stamp ~~Yes~~	No
Radiograph: SPOT		Stress Relieve:	
Type Supports: 4 LEGS			
Insulation: NO			
Fireproofing:			
Sandblast:		Paint:	
Manhole ☐ Hinged ☒ Davited		☐ Other:	
Platform Clips: YES	Ladder Clips: YES	Insul. Rings:	
Pipe Supports:			
Wind Load: 100 MPH (CBCCI)		Seismic: ZONE I (ANSI)	
Wt. E[illegible]	lb.	Wt. Full of Water	lb.

MATERIALS

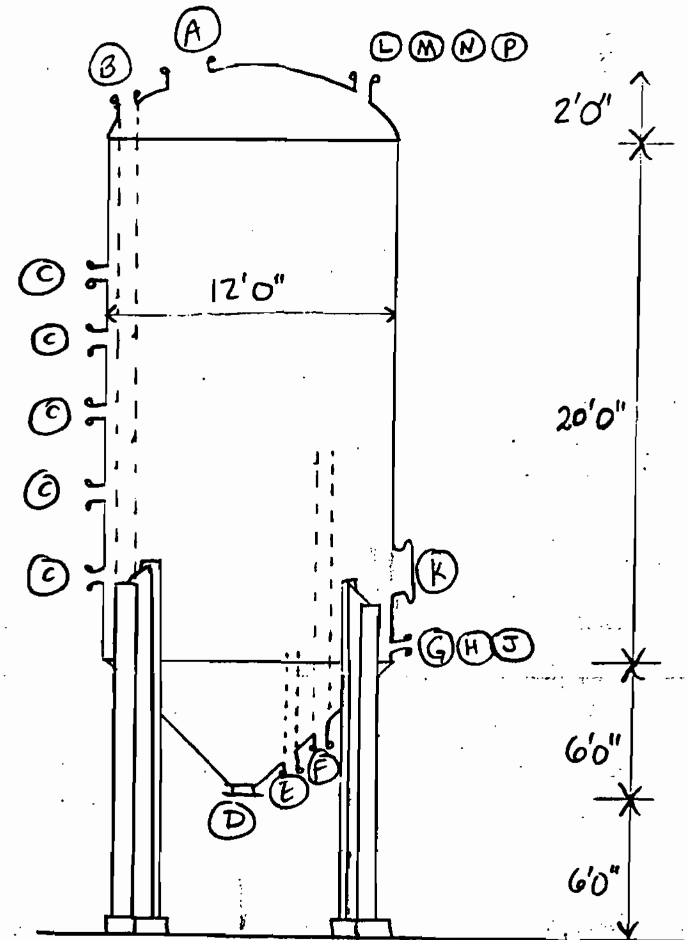
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	CS	A-285, Gr. C
Heads	5/16 in.	CS	A-285, Gr. C
Lining	in.		
	in.		
	in.		
Nozzle Necks		CS	
Flanges		CS	
Coupling			
M.H. Cover		CS	
Supports		CS	A36
Bolts/Studs		CS	
Nuts		CS	
Gaskets		TEFLON	

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
MANWAY/PSV HATCH	A	1	24"	150#	RF	FLG
FILL	B	1	4"			
SAMPLE	C	5	1"			
PUMP SUCTION	D	1	6"			
PUMP SUCTION	E	1	4"			
PUMP SUCTION	F	1	4"			
LEVEL TRANS.	G	2	4"			
TEMPERATURE	H	1	2"			
SPARE	J	1	4"			
MANWAY	K	1	24"			
PRE[illegible]E TRANS	L	1	2"			
VE[illegible]	M	2	3"			
LSHH	N	1	4"			
SPARE	P	1	4"	↓	↓	↓
	Q					
	R					

Nozzle to be Plugged or Blinded

TANK SKETCH



Only two of four legs shown for purpose of clarity.

Note: All dimensions are approximate

WES 15-0186

International Waste Energy Systems

VERTICAL TANK DATA SHEET

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SPECIFICATION NO. ______
EQUIPMENT NO. T-16

SHEET __ OF __
DATE: 09/05/89
REV: C-2
BY: LDC
CHK'D BY: JAD, JS, RWG 8/27/90

PROJECT NAME: FFPI
EQUIPMENT NAME/APPLICATION: SLUDGE HOLDING TANK-ORGANIC WASTE
WES PROJECT No. 8813

DESIGN DATA

Operating Pressure	psig	+4"WC to 18" WC	
Operating Temperature	°F	20° to 120°	
Liquid Specific Gravity		1.70	
Contents Lethal		~~Yes~~	No
Design Pressure	psig	-10" WC to 5 PSIG	
Design Temperature	°F	150°	
CAPACITY		19,500 gal	
HEATING		External Steam Coils	
Hydrostatic Test	psig	15	
Shell / Heads Corr. Allow.	in.	1/8	1/8
Shell / Heads Joint Eff.	%	85	85
Code: API 620		Stamp ~~Yes~~	No
Radiograph: YES		Stress Relieve:	
Type Supports: 6 LEGS			
Insulation:			
Fireproofing:			
Sandblast:		Paint:	
Manhole ☐ Hinged	☒ Davited	☐ Other:	
Platform Clips: YES	Ladder Clips:	Insul. Rings:	
Pipe Supports:			
Wind Load: 100 MPH (SBCCI)		Seismic: ZONE I (ANSI)	
Wt. Empty	lb.	Wt. Full of Water	lb.

MATERIALS

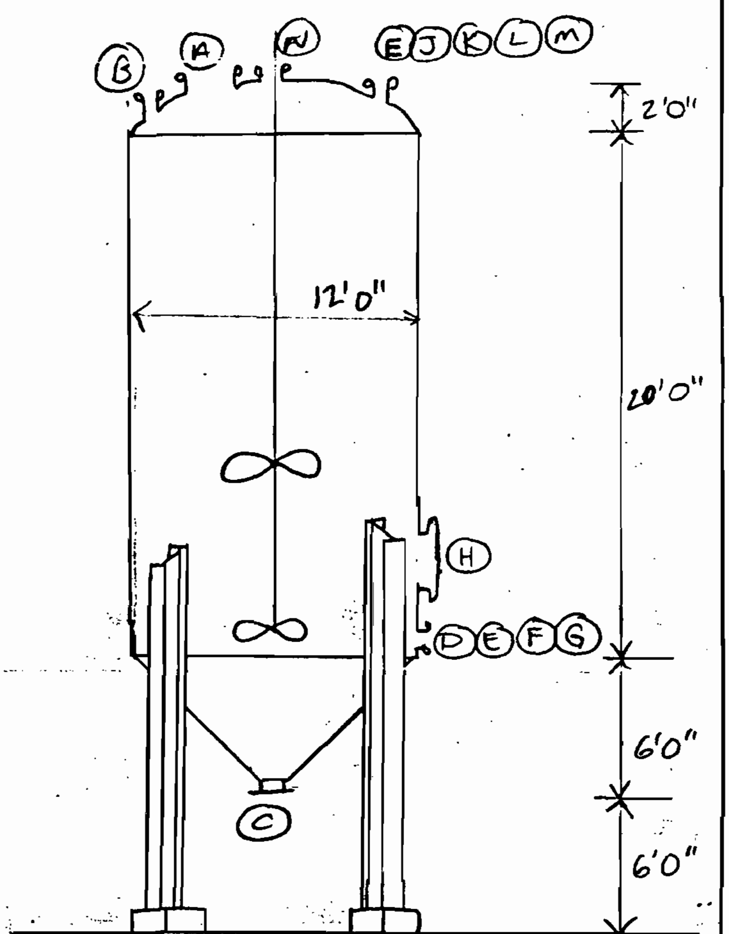
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	CS	A285, Gr. C
Heads	5/16 in.	CS	A285, Gr. C
Lining	in.		
	in.		
	in.		
Nozzle Necks		CS	
Flanges		CS	
Coupling			
M.H. Cover		CS	
Supports		CS	A36
Bolts/Studs		CS	
Nuts		CS	
Gaskets	TEFLON		

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
MANWAY/PSV	A	1	24"	150#	RF	FLG
FILL	B	1	4"			
PUMP SUCTION	C	1	6"			
FEED RECYCLE	D	1	4"			
LEVEL TRANS.	E	2	4"			
TEMPERATURE	F	1	2"			
SPARE	G	1	4"			
MANWAY	H	1	24"			
PRESSURE TR	J	1	2"			
VENT	K	2	3"			
LS	L	1	4"			
SPARE	M	1	4"			
AGITATOR	N	1				
	P					
	Q					
	R					

Nozzle to be Plugged or Blinded

TANK SKETCH



Only two of six legs shown for purpose of clarity.

Note: All dimensions are approximate

WES 15-0186

International Waste Energy Systems

SPECIFICATION NO. ______
EQUIPMENT NO. T-17

DATE: 09/05/89
REV: C-2
BY: LDC
CHK'D BY: JAO, JS

PROJECT NAME: FFPI
EQUIPMENT NAME/APPLICATION: SLUDGE FEED TANK - ORGANIC WASTE
IWES PROJECT No. 8813

DESIGN DATA

Operating Pressure	psig	+4" WC to +18" WC	
Operating Temperature	°F	20 to 120	
Liquid Specific Gravity		1.70	
Contents Lethal		~~Yes~~	No
Design Pressure	psig	-10" WC to 5 PSIG	
Design Temperature	°F	150°	
CAPACITY		8000 gal	
HEATING		External Steam Coils	
Hydrostatic Test	psig	15	
Shell / Heads Corr. Allow.	in.	1/8	1/8
Shell / Heads Joint Eff.	%	85	85
Code: API 620		Stamp ~~Yes~~	No
Radiograph: SPOT		Stress Relieve:	
Type Supports: 6 LEGS			
Insulation: YES			
Fireproofing:			
Sandblast:		Paint:	
Manhole ☐ Hinged ☒ Davited		☐ Other:	
Platform Clips: YES	Ladder Clips:	Insul. Rings:	
Pipe Supports:			
Wind Load: 100 mph (SBCCI)		Seismic: ZONE I (ANSI)	
Wt. Empty lb.		Wt. Full of Water lb.	

MATERIALS

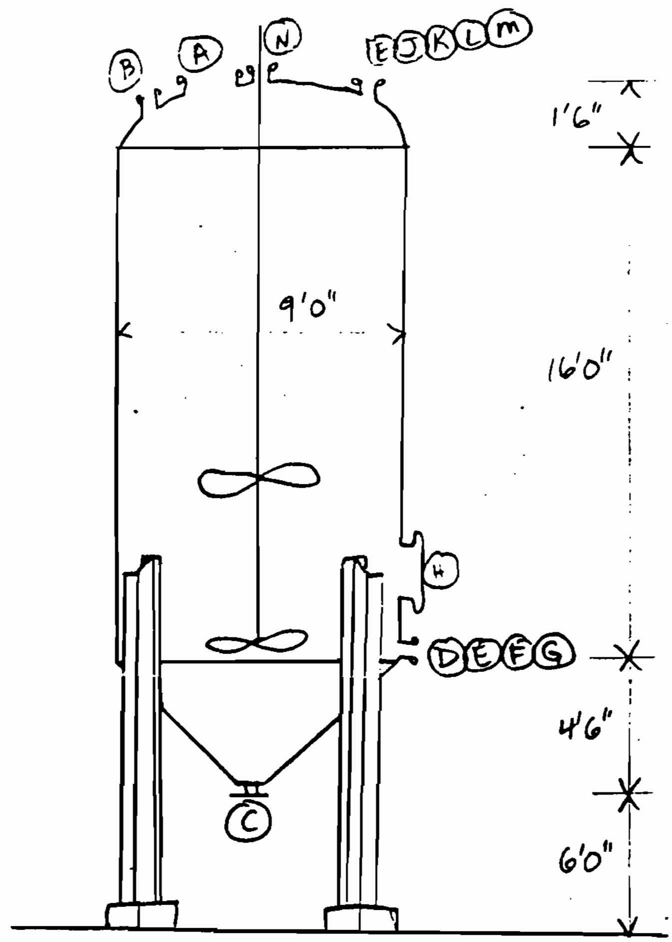
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	CS	A 285, Gr. 'C'
Heads	5/16 in.	CS	A 285 Gr. 'C'
Lining	in.		
	in.		
	in.		
Nozzle Necks		CS	
Flanges		CS	
Coupling			
M.H. Cover		CS	
Supports		CS	A 36
Bolts/Studs		CS	
Nuts		CS	
Gaskets	TEFLON		

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
MANWAY/PSV	A	1	24"	150#	RF	FLG
FILL	B	1	4"	↓	↓	↓
PUMPSUCTION	C	1	6"	↓	↓	↓
FEED RECYCLE	D	1	4"	↓	↓	↓
LEVEL TRANS.	E	2	4"	↓	↓	↓
TEMPERATURE	F	1	2"	↓	↓	↓
SPARE	G	1	4"	↓	↓	↓
MANWAY	H	1	24"	↓	↓	↓
PRESSURE TRAN.	J	1	2"	↓	↓	↓
VENT	K	2	3"	↓	↓	↓
LSHH	L	1	4"	↓	↓	↓
SPARE	M	1	4"			
AGITATOR	N	1				
	P					
	Q					
	R					

*Nozzle to be Plugged or Blinded

TANK SKETCH



Only two of six legs shown for purpose of clarity.

Note: All dimensions are approximate

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SPECIFICATION NO.

EQUIPMENT NO. T-18, 19, 20

DATE: [illegible]

REV: C-2

BY: LDC

CHK'D BY: J.A.O., JS RWL

PROJECT NAME: FFPI

EQUIPMENT NAME/APPLICATION: HIGH-BTU/LOW-BTU LIQUID FEED TANK - ORGANIC WASTE

WES PROJECT No. 8813

DESIGN DATA

Operating Pressure	psig	+4" WC to +8" WC	
Operating Temperature	°F	20 to 120	
Liquid Specific Gravity		1.25	
Contents Lethal		Yes No	
Design Pressure	psig	-10" WC to +5 PSIG	
Design Temperature	°F	150	
Capacity		19,500 gal	
Hydrostatic Test	psig	15	
Shell / Heads Corr. Allow.	in.	1/8	1/8
Shell / Heads Joint Eff.	%	85	85
Code: API 620		Stamp Yes No	
Radiograph: SPOT		Stress Relieve:	
Type Supports: 6 LEGS			
Insulation: NO			
Fireproofing:			
Sandblast:		Paint:	
Manhole ☐ Hinged ☒ Davited ☐ Other:			
Platform Clips: YES	Ladder Clips: YES	Insul. Rings:	
Pipe Supports:			
Wind Load: 100 MPH (SBCCI)		Seismic: ZONE I (ANSI)	
Wt. Empty	lb.	Wt. Full of Water	lb.

MATERIALS

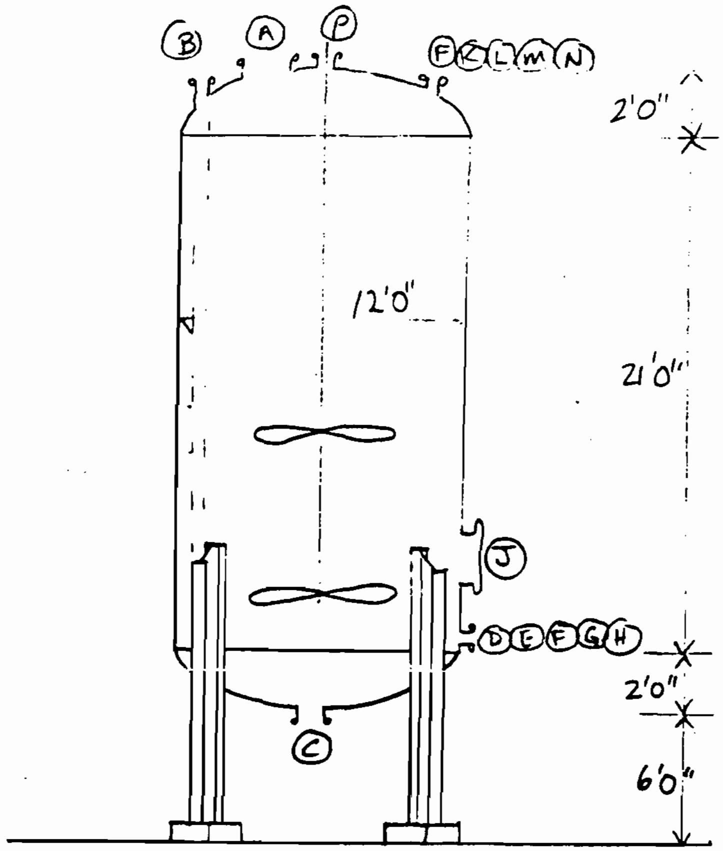
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	CS	A285, Gr. 'C'
Heads	5/16 in.	CS	A285, Gr. 'C'
Lining	in.		
	in.		
	in.		
Nozzle Necks		CS	
Flanges		CS	
Coupling			
M.H. Cover		CS	
Supports		CS	A36
Bolts/Studs		CS	
Nuts		CS	
Gaskets			

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
MANWAY/PSV	A	1	24"	150#	RF	FLG
FILL	B	1	4"	|	|	|
PUMP SUCTION	C	1	6"	|	|	|
PUMP SUCTION	D	1	2"	|	|	|
FEED RECYCLE	E	1	2"	|	|	|
LEVEL TRANS.	F	2	4"	|	|	|
TEMPERATURE	G	1	2"	|	|	|
SPARE	H	1	4"	|	|	|
MANWAY	J	1	24"	|	|	|
PRESSURE	K	1	2"	|	|	|
VENT	L	2	3"	|	|	|
LSHH	M	1	4"	|	|	|
SPARE	N	1	4"	|	|	|
AGITATOR	P	1		↓	V	V
	Q					
	R					

Nozzle to be Plugged or Blinded

TANK SKETCH



Only two of six legs shown for purpose of clarity.

Note: All dimensions are approximate

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VERTICAL TANK DATA SHEET

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SPECIFICATION NO. ____________

EQUIPMENT NO. T-21

DATE: 09/05/89
REV: C-2
BY: LDC
CHK'D BY: PB, JS

PROJECT NAME: FFPI

EQUIPMENT NAME/APPLICATION: ALKALINE/CYANIDE DRUM WASTE RECEIVING TANK (INORGANIC WASTE)

WES PROJECT No. 8813

DESIGN DATA

Operating Pressure psig	-0.15 to +0.30	
Operating Temperature °F	32° to 125°	
Liquid Specific Gravity	1.25	
Contents Lethal	~~Yes~~	No
Design Pressure psig	-0.30 to +0.45	
Design Temperature °F	180°	
Design pH	7-14	
Capacity	2000 gal	
Hydrostatic Test psig		
Shell / Heads Corr. Allow. in.		
Shell / Heads Joint Eff. %		
Code: NBS-PS 15-69	Stamp ~~Yes~~	No
Radiograph:	Stress Relieve:	
Type Supports: 4 LEGS		
Insulation:		
Fireproofing:		
Sandblast:	Paint:	
Manhole ☐ Hinged ☐ Davited	☐ Other:	
Platform Clips:	Ladder Clips:	Insul. Rings:
Pipe Supports:		
Wind Load: 100 MPH (SBCCI)	Seismic: ZONE I (ANSI)	
Wt. Empty lb.	Wt. Full of Water lb.	

MATERIALS

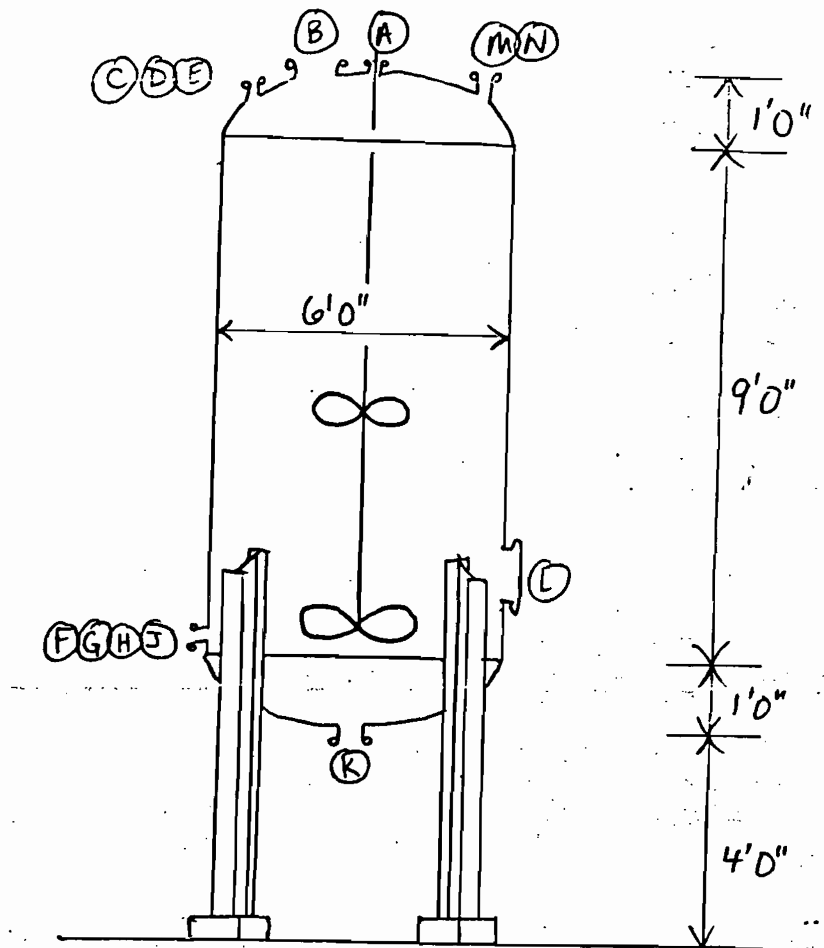
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	1/4 in.	FRP	ASTM D 3299
Heads	5/16 in.	FRP	ASTM D 3299
Lining	in.		
	in.		
	in.		
Nozzle Necks		FRP	
Flanges		FRP	
Coupling			
M.H. Cover		FRP	
Supports		CS	A36
Bolts/Studs			
Nuts			
Gaskets			

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
AGITATOR	A	1		150#		FLG.
MANWAY/PSV	B	1	24"	↓		↓
VENT	C	1	6"			
LSHH	D	1	2"			
LEVEL TRANSM	E	1	1"			
— " —	F	1	4"			
TEMPERATURE	G	1	2"			
SAMPLE POINT	H	1	1"			
SPARE	J	1	4"			
PUMP SUCTION	K	1	4"			
M[illegible]Y	L	1	24"			
SP[illegible]	M	1	4"			
FILL	N	1	4"	↓		↓
	P					
	O					
	R					

Nozzle to be Plugged or Blinded

TANK SKETCH



Only two of four legs shown for purpose of clarity.

Note: All dimensions are approximate

WES 15-0186

International Waste Energy Systems

VERTICAL TANK DATA SHEET

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SPECIFICATION NO.	
EQUIPMENT NO.	T-22
DATE:	09/06/89
REV:	C-2
BY:	FDC
CHK'D BY:	PB, JS

PROJECT NAME: FFPI

EQUIPMENT NAME/APPLICATION: ACIDIC/CHROMATE DRUM WASTE RECEIVING TANK (INORGANIC WASTE)

IWES PROJECT No. 8813

DESIGN DATA

Operating Pressure	psig	-0.15 to +0.30	
Operating Temperature	°F	32° to 125°	
Liquid Specific Gravity		1.25	
Contents Lethal		~~Yes~~	No
Design Pressure	psig	-0.30 to +0.45	
Design Temperature	°F	180°	
DESIGN pH		0-7	
CAPACITY		2000 gal	
Hydrostatic Test	psig		
Shell / Heads Corr. Allow.	in.		
Shell / Heads Joint Eff.	%		
Code: NBS-PS 15-69		Stamp Yes No	
Radiograph:		Stress Relieve:	
Type Supports: 4 LEGS			
Insulation:			
Fireproofing:			
Sandblast:		Paint:	
Manhole ☐ Hinged	☐ Davited	☐ Other:	
Platform Clips:	Ladder Clips:	Insul. Rings:	
Pipe Supports:			
Wind Load: 100 MPH (SBCCI)		Seismic: ZONE I (ANSI)	
Wt. Empty	lb.	Wt. Full of Water	lb.

MATERIALS

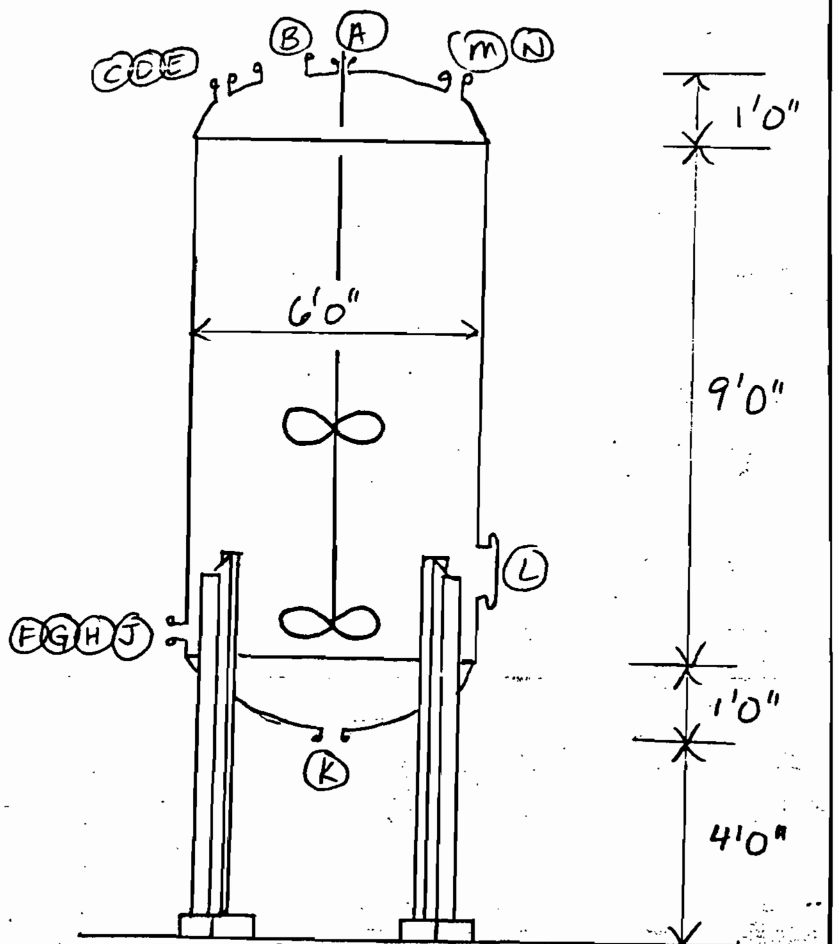
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	1/4 in.	FRP	ASTM D 3299
Heads	5/16 in.	FRP	ASTM D 3299
Lining	in.		
	in.		
	in.		
Nozzle Necks		FRP	
Flanges		FRP	
Coupling			
M.H. Cover		FRP	
Supports		CS	A36
Bolts/Studs			
Nuts			
Gaskets			

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
AGITATOR	A	1		150#		FLG
MANWAY/PSV	B	1	24"	↓		↓
VENT	C	1	6"			
LSHH	D	1	2"			
LEVEL TRANSM	E	1	1"			
- " -	F	1	4"			
TEMPERATURE	G	1	2"			
SAMPLE POINT	H	1	1"			
SPARE	J	1	4"			
PUMP SUCTION	K	1	4"			
M[illegible]Y	L	1	24"			
SP[illegible]	M	1	4"			
FILL	N	1	4"	↓		↓
	P					
	Q					
	R					

*Nozzle to be Plugged or Blinded

TANK SKETCH



Only two of four legs shown for purpose of clarity.

Note: All dimensions are approximate

IWES 15-0186

International Waste Energy Systems

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SPECIFICATION NO. ______

EQUIPMENT NO. T-23

DATE: 09/06/89
REV: C-2
BY: LDC
CHK'D BY: PB, JS

PROJECT NAME: FFPI

EQUIPMENT NAME/APPLICATION: DISSOLVED ALKALINE/CYANIDE WASTE HOLDING TANK (INORGANIC WASTE)

WES PROJECT No. 8813

DESIGN DATA

Operating Pressure	psig	-0.15 to +0.30
Operating Temperature	°F	32° to 125°
Liquid Specific Gravity		1.25
Contents Lethal		~~Yes~~ No
Design Pressure	psig	-0.30 to 0.45
Design Temperature	°F	180
DESIGN pH		7-14
CAPACITY		8000 gal
Hydrostatic Test	psig	
Shell / Heads Corr. Allow.	in.	
Shell / Heads Joint Eff.	%	
Code: NBS-PS 15-69		Stamp Yes No
Radiograph:		Stress Relieve:
Type Supports: 6 LEGS		
Insulation: NO		
Fireproofing:		
Sandblast:		Paint:
Manhole ☐ Hinged ☐ Davited ☐ Other:		
Platform Clips:	Ladder Clips: YES	Insul. Rings:
Pipe Supports:		
Wind Load: 100 MPH (SBCCI)		Seismic: ZONE I (ANSI)
Wt. Empty lb.		Wt. Full of Water lb.

MATERIALS

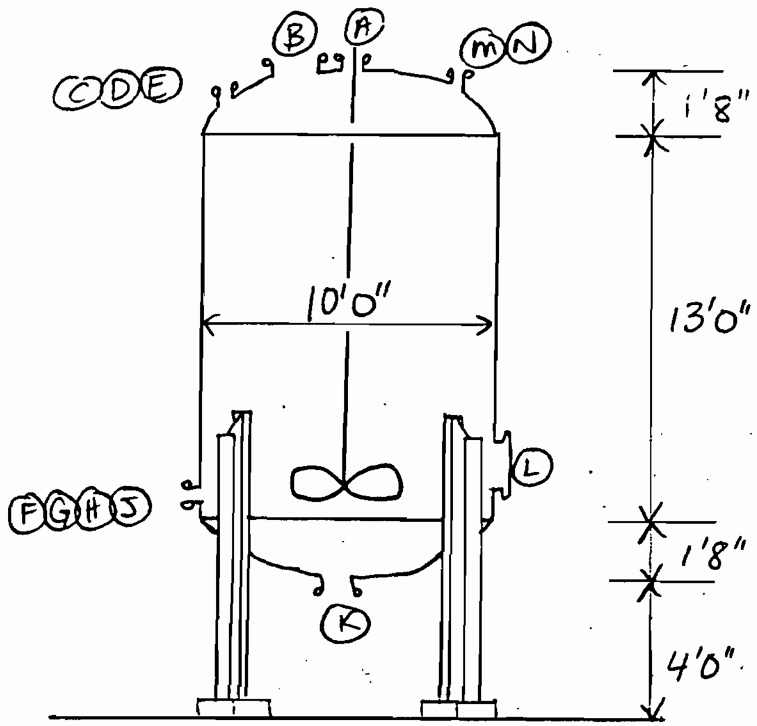
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	FRP	ASTM D 3299
Heads	3/8 in.	FRP	ASTM D 3299
Lining	in.		
	in.		
	in.		
Nozzle Necks		FRP	
Flanges		FRP	
Coupling			
M.H. Cover		FRP	
Supports		CS	A36
Bolts/Studs			
Nuts			
Gaskets			

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
AGITATOR	A	1		150#		FLG
MANWAY/PSV	B	1	24"			
VENT	C	1	6"			
LSHH	D	1	2"			
LEVEL TRANSM	E	1	1"			
-"-	F	1	4"			
TEMPERATURE	G	1	2"			
SAMPLE POINT	H	1	1"			
SPARE	J	1	4"			
PUMP SUCTION	K	1	4"			
MANWAY	L	1	24"			
SPARE	M	2	4"			
FILL	N	1	4"	↓		↓
	P					
	Q					
	R					

Nozzle to be Plugged or Blinded

TANK SKETCH



NOTES: - TANK TO BE PROVIDED WITH BAFFLES AND AGITATOR BRIDGE
FRP (POLYESTER) TO BE RESISTANT TOWARDS OXIDIZING ACIDS.
- Only two of six legs shown for purpose of clarity.
- All dimensions are approximate

WES 15-0186

International Waste Energy Systems

VERTICAL TANK DATA SHEET

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SPECIFICATION NO. ______

EQUIPMENT NO. T-24

SHEET: ______
DATE: 09/06/89
REV: C-2
BY: LDC
CHK'D BY: PB, JS

PR[illegible]CT NAME: EFPI

EQUIPMENT NAME/APPLICATION: DISSOLVED ACIDIC/CARDMATE WASTE HOLDING TANK (INORGANIC WASTE)

IWES PROJECT No. 8813

DESIGN DATA

Operating Pressure psig	-0.15 to +0.30		
Operating Temperature °F	32° to 125°		
Liquid Specific Gravity	1.25		
Contents Lethal	~~Yes~~ No		
Design Pressure psig	-0.3 to +0.45		
Design Temperature °F	180		
DESIGN pH	0-7		
CAPACITY	8000 gal.		
Hydrostatic Test psig			
Shell / Heads Corr. Allow. in.			
Shell / Heads Joint Eff. %			
Code: NBS-PS 15-69	Stamp Yes No		
Radiograph:	Stress Relieve:		
Type Supports: 6 LEGS			
Insulation: NO			
Fireproofing:			
Sandblast:	Paint:		
Manhole ☐ Hinged	☐ Davited	☐ Other:	
Platform Clips:	Ladder Clips: YES	Insul. Rings:	
Pipe Supports:			
Wind Load: 100 MPH (SBCCI)	Seismic: ZONE I (ANSI)		
Wt. Empty lb.	Wt. Full of Water lb.		

MATERIALS

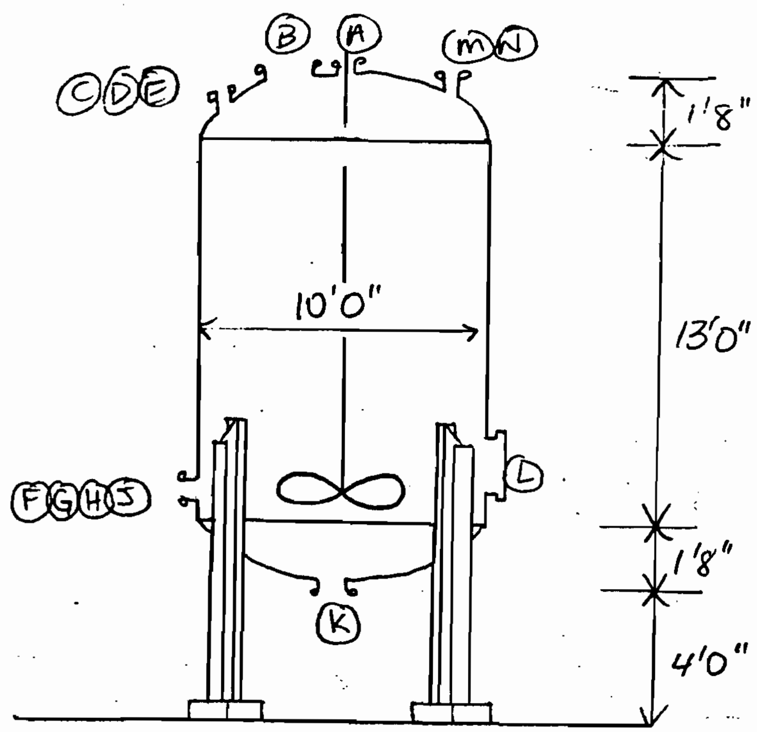
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	FRP	ASTM D 3299
Heads	3/8 in.	FRP	ASTM D 3299
Lining	in.		
	in.		
	in.		
Nozzle Necks		FRP	
Flanges		FRP	
Coupling			
M.H. Cover		FRP	
Supports		CS	A36
Bolts/Studs			
Nuts			
Gaskets			

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
AGITATOR	A	1		150#		FLG
MANWAY/PSV	B	1	24"	↓		↓
VENT	C	1	6"			
LSHH	D	1	2"			
LEVEL TRANSM	E	1	1"			
— " —	F	1	4"			
TEMPERATURE	G	1	2"			
SAMPLE POINT	H	1	1"			
SPARE	J	1	4"			
PUMP SUCTION	K	1	4"			
MA[illegible]Y	L	1	24"			
SP[illegible]	M	2	4"			
FILL	N	1	4"	↓		↓
	P					
	Q					
	R					

*Nozzle to be Plugged or Blinded

TANK SKETCH



NOTE: TANK TO BE PROVIDED WITH BAFFLES AND AGITATOR BRIDGE

- Only two of six legs shown for purpose of clarity.
- All dimensions are approximate

IWES 15-0186

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SPECIFICATION NO. ____

EQUIPMENT NO. T-25, 26, 27, 28, 29, 30

DATE: 09/06/89
REV: C-2
BY: LDC
CHK'D BY: PB, JS

PROJECT NAME: FFPI

EQUIPMENT NAME/APPLICATION: CHROMATE WASTE STORAGE TANK - INORGANIC WASTE

IWES PROJECT No. 8813

DESIGN DATA

Operating Pressure	psig	-0.15 to +0.30
Operating Temperature	°F	32° - 125°
Liquid Specific Gravity		1.25
Contents Lethal		~~Yes~~ No
Design Pressure	psig	-0.30 to +0.45
Design Temperature	°F	180
DESIGN pH		0-7
CAPACITY		8000 gal
Hydrostatic Test	psig	
Shell / Heads Corr. Allow.	in.	
Shell / Heads Joint Eff.	%	
Code: NBS-PS 15-69		Stamp Yes No
Radiograph:		Stress Relieve:
Type Supports: 6 LEGS		
Insulation: NO		
Fireproofing:		
Sandblast:		Paint:
Manhole ☐ Hinged ☐ Davited ☐ Other:		
Platform Clips: YES	Ladder Clips: YES	Insul. Rings:
Pipe Supports:		
Wind Load: 100 MPH (SBCCI)		Seismic: ZONE I (ANSI)
Wt. Empty lb.		Wt. Full of Water lb.

MATERIALS

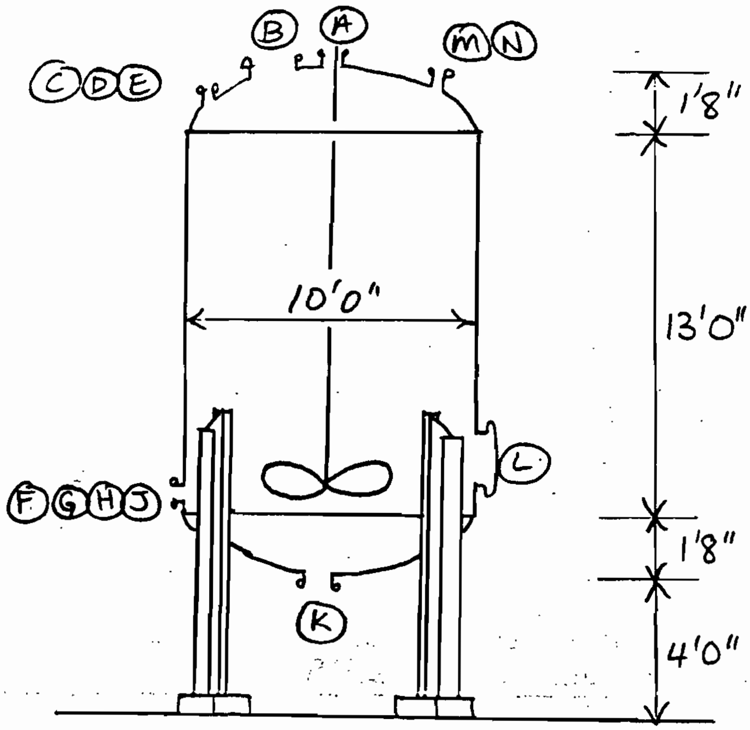
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	FRP	ASTM D 3299
Heads	3/8 in.	FRP	ASTM D 3299
Lining	in.		
	in.		
	in.		
Nozzle Necks		FRP	
Flanges		FRP	
Coupling			
M.H. Cover		FRP	
Supports		CS	A36
Bolts/Studs			
Nuts			
Gaskets			

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
AGITATOR	A	1		150#		FLG
MANWAY/PSV	B	1	24"	↓		↓
VENT	C	1	6"			
LSHH	D	1	2"			
LEVEL TRANSM	E	1	1"			
-"-	F	1	4"			
TEMPERATURE	G	1	2"			
SAMPLE POINT	H	1	1"			
SPARE	J	1	4"			
PUMP SUCTION	K	1	4"			
MANWAY	L	1	24"			
SPARE	M	2	4"			
FILL	N	1	4"	↓		↓
	P					
	Q					
	R					

Nozzle to be Plugged or Blinded

TANK SKETCH



NOTES: - TANK TO BE PROVIDED WITH BAFFLES AND AGITATOR BRIDGE
FRP (POLYESTER) TO BE RESISTANT TOWARDS OXIDIZING ACIDS
- Only two of six legs shown for purpose of clarity.
- All dimensions are approximate

WES 15-0186

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SPECIFICATION NO. ______

EQUIPMENT NO. T-31, 32, 33, 34

DATE: 09/06/89
REV: C-2
BY: LDC
CHK'D BY: PB, JS

PROJECT NAME: FFPI
EQUIPMENT NAME/APPLICATION: ACIDIC WASTE STORAGE TANK-INORGANIC WASTE
WES PROJECT No. 8813

DESIGN DATA

Operating Pressure	psig	-0.15 to +0.30
Operating Temperature	°F	32° to 125°
Liquid Specific Gravity		1.25
Contents Lethal		~~Yes~~ No
Design Pressure	psig	-0.30 to 0.45
Design Temperature	°F	180°
DESIGN pH		0-7
CAPACITY		8000 gal
Hydrostatic Test	psig	
Shell / Heads Corr. Allow.	in.	
Shell / Heads Joint Eff.	%	
Code: NBS-PS 15-69		Stamp Yes No
Radiograph:		Stress Relieve:
Type Supports: 6 LEGS		
Insulation: NO		
Fireproofing:		
Sandblast:		Paint:
Manhole ☐ Hinged ☐ Davited ☐ Other:		
Platform Clips: YES	Ladder Clips: YES	Insul. Rings:
Pipe Supports:		
Wind Load: 100 MPH (SBCC)		Seismic: ZONE I
Wt. Empty lb.		Wt. Full of Water lb.

MATERIALS

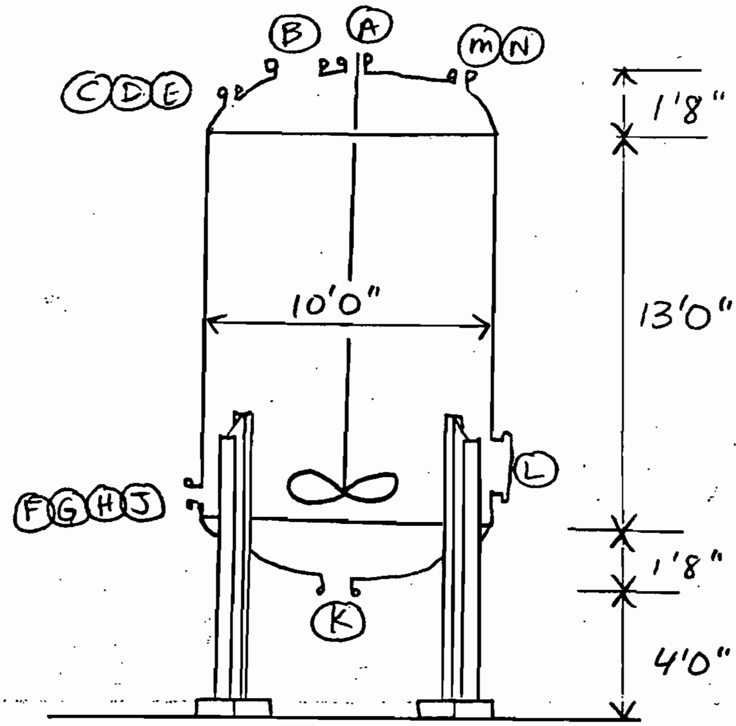
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	FRP	ASTM D 3299
Heads	3/8 in.	FRP	ASTM D 3299
Lining	in.		
	in.		
	in.		
Nozzle Necks		FRP	
Flanges		FRP	
Coupling			
M.H. Cover		FRP	
Supports		CS	A36
Bolts/Studs			
Nuts			
Gaskets			

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
AGITATOR	A	1		150#		FLG
MANWAY/PSV	B	1	24"	↓		↓
VENT	C	1	6"			
LSHH	D	1	2"			
LEVEL TRANSM	E	1	1"			
-"-	F	1	4"			
TEMPERATURE	G	1	2"			
SAMPLE POINT	H	1	1"			
SPARE	J	1	4"			
PUMP SUCTION	K	1	4"			
MANWAY	L	1	24"			
SPARE	M	2	4"			
FILL	N	1	4"	↓		↓
	P					
	Q					
	R					

Nozzle to be Plugged or Blinded

TANK SKETCH



NOTES:- TANKS TO BE PROVIDED WITH BAFFLES AND AGITATOR BRIDGE

FRP (POLYESTER) TO BE RESISTANT TOWARDS OXIDIZING ACIDS.

- Only two of six legs shown for purpose of clarity.
- All dimensions are approximate

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SPECIFICATION NO. ______
EQUIPMENT NO. T-35, 36

DATE: 09/06/89
REV: C-2
BY: LDC
CHK'D BY: PB, JS

PROJECT NAME: FFPI
EQUIPMENT NAME/APPLICATION: ALKALINE WASTE STORAGE TANK - INORGANIC WASTE
WES PROJECT No. 8813

DESIGN DATA

Operating Pressure psig	-0.15 to +0.30	
Operating Temperature °F	32° to 125°	
Liquid Specific Gravity	1.25	
Contents Lethal	~~Yes~~	No
Design Pressure psig	-0.3 to +0.45	
Design Temperature °F	180°	
DESIGN pH	7-14	
CAPACITY	8000 gal	
Hydrostatic Test psig		
Shell / Heads Corr. Allow. in.		
Shell / Heads Joint Eff. %		
Code: NBS-PS 15-69	Stamp Yes	No
Radiograph:	Stress Relieve:	
Type Supports: 6 LEGS		
Insulation: NO		
Fireproofing:		
Sandblast:	Paint:	
Manhole ☐ Hinged ☐ Davited ☐ Other:		
Platform Clips: YES	Ladder Clips:	Insul. Rings:
Pipe Supports:		
Wind Load: 100 MPH (SBCCI)	Seismic: ZONE I (ANSI)	
Wt. Empty lb.	Wt. Full of Water lb.	

MATERIALS

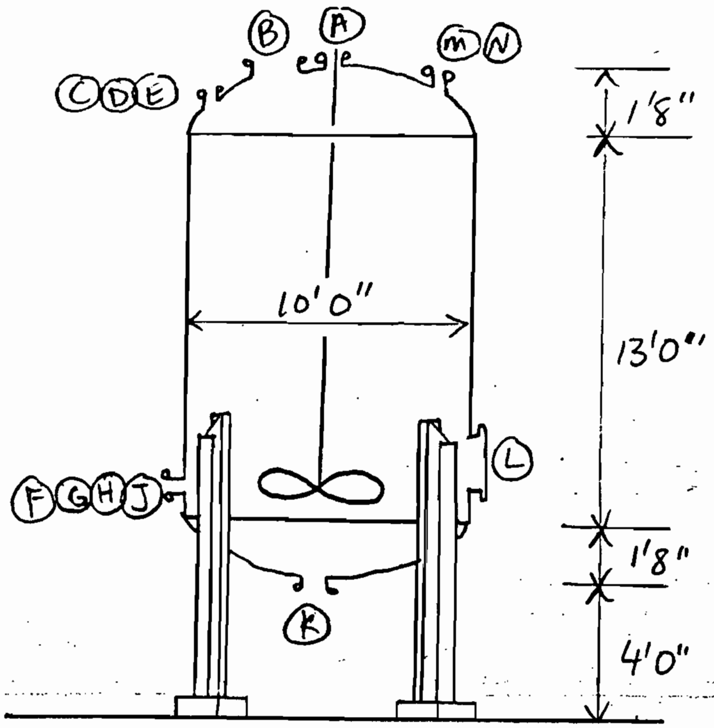
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	FRP	ASTM D 3299
Heads	3/8 in.	FRP	ASTM D 3299
Lining	in.		
	in.		
	in.		
Nozzle Necks		FRP	
Flanges		FRP	
Coupling			
M.H. Cover		FRP	
Supports		CS	A 36
Bolts/Studs			
Nuts			
Gaskets			

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
AGITATOR	A	1		150#		FLG
MANWAY/PSV	B	1	24"			
VENT	C	1	6"			
LSHH	D	1	2"			
LEVEL TRANSM	E	1	1"			
— " —	F	1	4"			
TEMPERATURE	G	1	2"			
SAMPLE POINT	H	1	1"			
SPARE	J	1	4"			
PUMP SUCTION	K	1	4"			
MANWAY	L	1	24"			
SPARE	M	2	4"			
FILL	N	1	4"			
	P					
	Q					
	R					

Nozzle to be Plugged or Blinded

TANK SKETCH



NOTE: - TANK TO BE PROVIDED WITH BAFFLES AND AGITATOR BRIDGE.
- Only two of six legs shown for purpose of clarity.
- All dimensions are approximate

WES 15-0186

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VERTICAL TANK DATA SHEET

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SHEET ___ OF ___
DATE: 09-06-89
REV: C-2
BY: LDC
CHK'D BY: PB, JS

SPECIFICATION NO. ____________
EQUIPMENT NO. T-37, 38

PROJECT NAME: FFPI
EQUIPMENT NAME/APPLICATION: CYANIDE WASTE STORAGE TANK-INORGANIC WASTE
IWES PROJECT No. 8813

DESIGN DATA

Operating Pressure	psig	-0.15 to +0.30
Operating Temperature	°F	32° to 125°
Liquid Specific Gravity		1.25
Contents Lethal		~~Yes~~ No
Design Pressure	psig	-0.30 to +0.45
Design Temperature	°F	180°
DESIGN pH		7-14
CAPACITY		8000 gal
Hydrostatic Test	psig	
Shell / Heads Corr. Allow.	in.	
Shell / Heads Joint Eff.	%	
Code: NBS-PS 15-69		Stamp Yes No
Radiograph:		Stress Relieve:
Type Supports: 6 LEGS		
Insulation: NO		
Fireproofing:		
Sandblast:		Paint:
Manhole ☐ Hinged ☒ Davited		☐ Other:
Platform Clips: YES	Ladder Clips: YES	Insul. Rings:
Pipe Supports:		
Wind Load: 100 MPH (SBCCI)		Seismic: ZONE I (ANSI)
Wt. Empty lb.		Wt. Full of Water lb.

MATERIALS

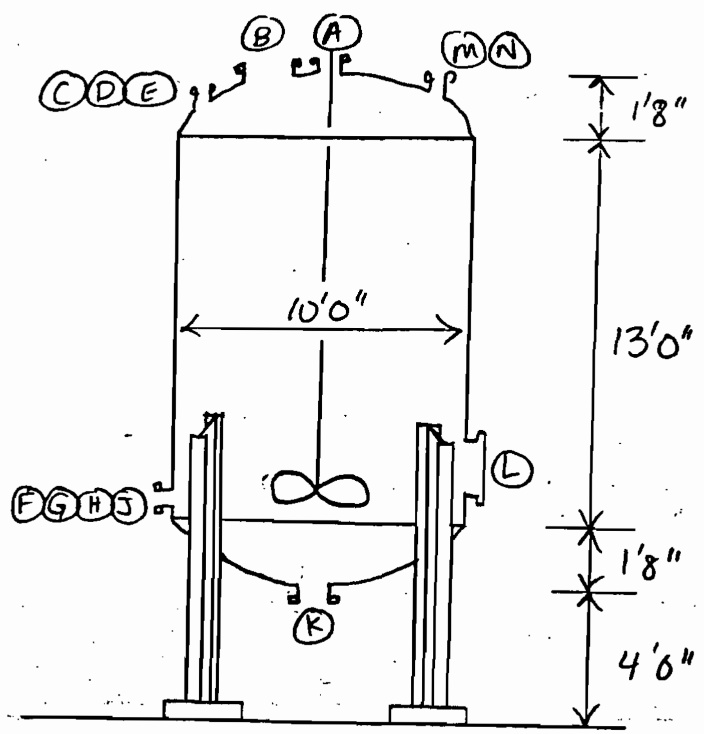
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	FRP	ASTM D 3299
Heads	3/8 in.	FRP	ASTM D 3299
Lining	in.		
	in.		
	in.		
Nozzle Necks		FRP	
Flanges		FRP	
Coupling			
M.H. Cover		FRP	
Supports		CS	A36
Bolts/Studs			
Nuts			
Gaskets			

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
AGITATOR	A	1		150#		FLG
MANWAY/PSV	B	1	24"	↓		↓
VENT	C	1	6"			
LSHH	D	1	2"			
LEVEL TRANSM.	E	1	1"			
-II-	F	1	4"			
TEMPERATURE	G	1	2"			
SAMPLE POINT	H	1	1"			
SPARE	J	1	4"			
PUMP SUCTION	K	1	4"			
MANWAY	L	1	24"			
SPARE	M	2	4"			
FILL	N	1	4"	↓		↓
	P					
	Q					
	R					

*Nozzle to be Plugged or Blinded

TANK SKETCH



NOTES: - TANK TO BE PROVIDED WITH BAFFLES AND AGITATOR BRIDGE
- Only two of six legs shown for purpose of clarity.
- All dimensions are approximate

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SPECIFICATION NO. ________
EQUIPMENT NO. T-44,45,46

DATE: 09/06/89
REV: C-2
BY: LDC
CHK'D BY: PB, JS, RWG 8/27/90

PROJECT NAME: FFPI
EQUIPMENT NAME/APPLICATION: MULTIPURPOSE REACTOR–INORGANIC WASTE
IWES PROJECT No. 8813

DESIGN DATA

Operating Pressure	psig	-0.15 to +0.30	
Operating Temperature	°F	32° to 125°	
Liquid Specific Gravity		1.25	
Contents Lethal		Yes (crossed out)	No
Design Pressure	psig	-0.30 to +0.45	
Design Temperature	°F	180°	
DESIGN pH, see note		1 to 12	
CAPACITY		8000 gal.	
Hydrostatic Test	psig		
Shell / Heads Corr. Allow.	in.		
Shell / Heads Joint Eff.	%		
Code: NBS-PS 15-69		Stamp	Yes / No
Radiograph:		Stress Relieve:	
Type Supports: 6 LEGS			
Insulation:			
Fireproofing:			
Sandblast:		Paint:	
Manhole ☒ Hinged	☒ Davited	☐ Other:	
Platform Clips: YES	Ladder Clips: YES	Insul. Rings:	
Pipe Supports:			
Wind Load: 100 MPH (SBCCI)		Seismic: ZONE I (ANSI)	
Wt. E[illegible]	lb.	Wt. Full of Water	lb.

MATERIALS

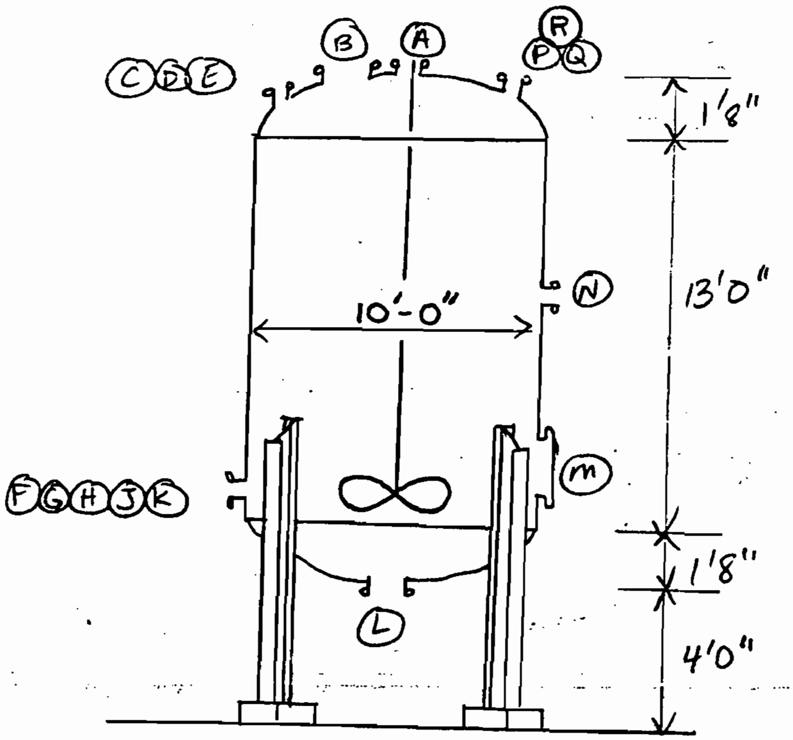
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	FRP	ASTM D 3299
Heads	3/8 in.	FRP	ASTM D 3299
Lining	in.		
	in.		
	in.		
Nozzle Necks		FRP	
Flanges		FRP	
Coupling			
M.H. Cover		FRP	
Supports		CS	A36
Bolts/Studs			
Nuts			
Gaskets			

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
AGITATOR	A	1		150#		FLG
MANWAY/PSV	B	1	24"			
VENT	C	1	6"			
LSHH	D	1	2"			
LEVEL TRANSM	E	1	1"			
- " -	F	1	4"			
TEMPERATURE	G	1	2"			
SAMPLE POINT	H	1	1"			
SPARE	J	1	4"			
pH / [illegible]H LOOPS	K	4	1"			
PU[illegible]CTION	L	1	6"			
MA[illegible]AY	M	1	24"			
RECYCLE/COOLING	N	1	4"			
SPARE	P	3	4"			
FILL	Q	9	4"			
FILL	R	2	2"	↓		↓

Nozzle to be Plugged or Blinded

TANK SKETCH



NOTES: - TANK TO BE PROVIDED WITH BAFFLES AND AGITATOR BRIDGE.
DIPTUBES TO HAVE SIPHON HOLES TO PREVENT BACK-SIPHONING.
TOP MANWAY TO BE HINGED, SIDE MANWAY TO BE DAVITED
FRP (POLYESTER) TO BE RESISTANT TOWARDS OXIDIZING ACIDS AT LOW pH.
- Only two of six legs shown for purpose of clarity.
- All dimensions are approximate

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VERTICAL TANK DATA SHEET

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SPECIFICATION NO. ______

EQUIPMENT NO. T-47

DATE: 09/06/89
REV: C-2
BY: LDC
CHK'D BY: PB, JS

PROJECT NAME: FFPI
EQUIPMENT NAME/APPLICATION: CYANIDE REACTOR - INORGANIC WASTE
IWES PROJECT No. 8813

DESIGN DATA

Operating Pressure	psig	-0.15 to +0.30
Operating Temperature	°F	32° to 125°
Liquid Specific Gravity		1.25
Contents Lethal		~~Yes~~ No
Design Pressure	psig	-0.30 to +0.45
Design Temperature	°F	180°
DESIGN pH		7-14
CAPACITY		8000 gal
Hydrostatic Test	psig	
Shell	Heads Corr. Allow. in.	
Shell	Heads Joint Eff. %	
Code: NBS-PS 15-69		Stamp Yes No
Radiograph:		Stress Relieve:
Type Supports: 6 LEGS		
Insulation: NO		
Fireproofing:		
Sandblast:		Paint:
Manhole ☒ Hinged ☒ Davited		☐ Other: SEE NOTE
Platform Clips: YES	Ladder Clips: YES	Insul. Rings:
Pipe Supports:		
Wind Load: 100 mPH (SBCCI)		Seismic: ZONE I (ANSI)
Wt. Empty lb.		Wt. Full of Water lb.

MATERIALS

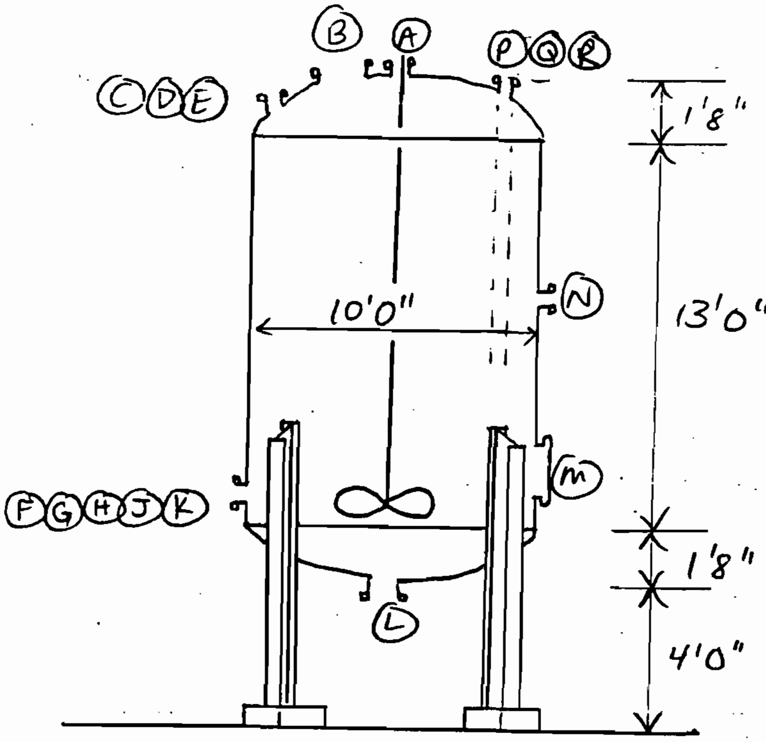
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	FRP	ASTM D 3299
Heads	3/8 in.	FRP	ASTM D 3299
Lining	in.		
	in.		
	in.		
Nozzle Necks		FRP	
Flanges		FRP	
Coupling			
M.H. Cover		FRP	
Supports	CS -		A36
Bolts/Studs			
Nuts			
Gaskets			

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
AGITATOR	A	1		150#		FLG
MANWAY/PSV	B	1	24"			
VENT	C	1	6"			
LSHH	D	1	2"			
LEVEL TRANSM.	E	1	1"			
— " —	F	1	4"			
TEMPERATURE	G	1	2"			
SAMPLE POINT	H	1	1"			
SPARE	J	1	4"			
pH/rH LOOPS	K	4	1"			
PUMP SUCTION	L	1	6"			
MANWAY	M	1	24"			
RECYCLE/COOLING	N	1	4"			
SPARE	P	3	4"			
FILL	Q	5	4"			
FILL	R	3	2"	↓		↓

Nozzle to be Plugged or Blinded

TANK SKETCH



NOTES: - TANK TO BE PROVIDED WITH BAFFLES AND AGITATOR BRIDGE.
- DIPTUBES TO HAVE SIPHON HOLES TO PREVENT BACK-SIPHONING.
- TOP MANWAY to BE HINGED.
- SIDE MANWAY to BE DAVITED.
- Only two of six legs shown for purpose of clarity.
- All dimensions are approximate

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SPECIFICATION NO. ______
EQUIPMENT NO. T-48, 49

DATE: 04/06/87
REV: C-2
BY: LDC
CHK'D BY: PB, JS

PROJECT NAME: FFPI
EQUIPMENT NAME/APPLICATION: FILTER FEED TANK - INORGANIC WASTE
WES PROJECT No. 3813

DESIGN DATA

Operating Pressure psig	-0.15 to +0.30	
Operating Temperature °F	32° to 125°	
Liquid Specific Gravity	1.25	
Contents Lethal	Yes	No
Design Pressure psig	-0.30 to +0.45	
Design Temperature °F	180°	
DESIGN pH	8-12	
CAPACITY	25,000 gal	
Hydrostatic Test psig		
Shell / Heads Corr. Allow. in.	1/8"	1/8"
Shell / Heads Joint Eff. %	85	85
Code: NBS-PS 15-69	Stamp Yes No	
Radiograph:	Stress Relieve:	
Type Supports: 4 LEGS		
Insulation:		
Fireproofing:		
Sandblast:	Paint:	
Manhole ☐ Hinged ☒ Davited ☐ Other:		
Platform Clips: Ladder Clips: Insul. Rings:		
Pipe Supports:		
Wind Load: 100 MPH (SBCCI)	Seismic: ZONE I / ANSI	
Wt. Empty lb.	Wt. Full of Water lb.	

MATERIALS

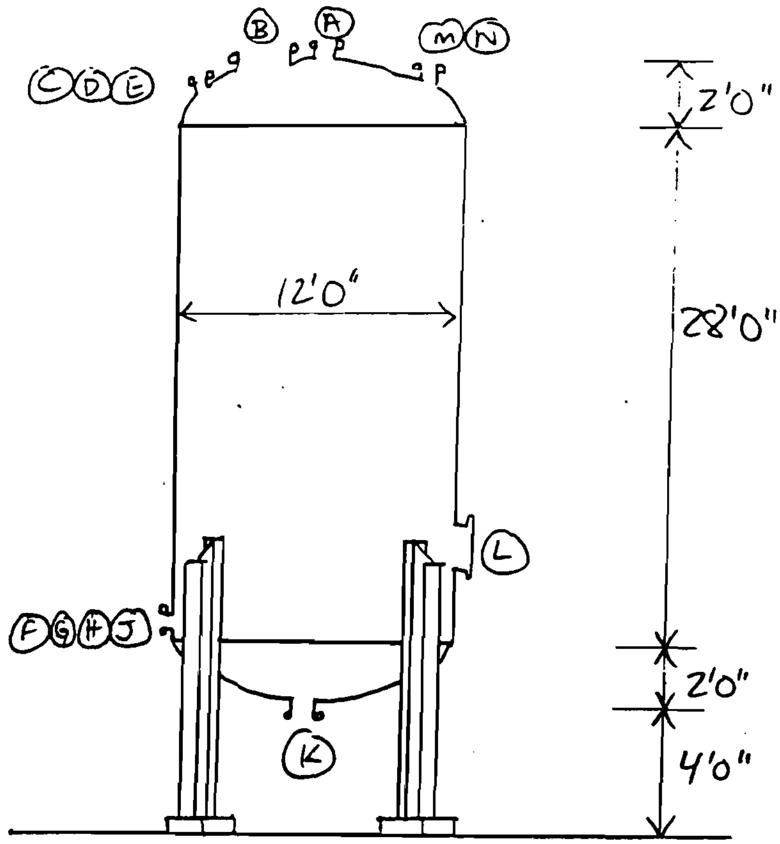
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	FRP	ASTM D 3299
Heads	5/16 in.	FRP	ASTM D 3299
Lining	in.		
	in.		
	in.		
Nozzle Necks	FRP		
Flanges	FRP		
Coupling			
M.H. Cover	FRP		
Supports	CS		A36
Bolts/Studs			
Nuts			
Gaskets			

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
AGITATOR	A	1		150#		FLG
MANWAY/PSV	B	1	24"	↓		↓
VENT	C	1	6"			
LSHH	D	1	2"			
LVL TRANSM	E	1	1"			
"	F	1	4"			
TEMPERATURE	G	1	2"			
SAMPLE POINT	H	1	1"			
SPARE	J	1	4"			
PUMP SUCTION	K	1	4"			
MANWAY	L	1	24"			
SPARE	M	1	4"			
FILL	N	2	4"	↓		↓
	P					
	Q					
	R					

Nozzle to be Plugged or Blinded

TANK SKETCH



Only two of four legs shown for purpose of clarity.

Note: All dimensions are approximate

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SPECIFICATION NO. ____
EQUIPMENT NO. T-50, 51

DATE: 09/06/84
REV: C
BY: LDC
CHK'D BY: PB, JS

PROJECT NAME: FFPI
EQUIPMENT NAME/APPLICATION: FILTRATE HOLDING TANK - INORGANIC WASTE
WES PROJECT No. 8813

DESIGN DATA

Operating Pressure	psig	-0.15 to +0.30	
Operating Temperature	°F	32° to 125°	
Liquid Specific Gravity		1.10	
Contents Lethal		~~Yes~~	No
Design Pressure	psig	-0.30 to +0.45	
Design Temperature	°F	180°	
DESIGN pH		8-12	
CAPACITY		8000 gal	
Hydrostatic Test	psig		
Shell / Heads Corr. Allow.	in.	1/8"	1/8"
Shell / Heads Joint Eff.	%	85	85
Code: NBS-PS 15-69		Stamp ~~Yes~~	No
Radiograph:		Stress Relieve:	
Type Supports: 4 LEGS			
Insulation:			
Fireproofing:			
Sandblast:		Paint:	
Manhole ☐ Hinged	☒ Davited	☐ Other:	
Platform Clips:	Ladder Clips:	Insul. Rings:	
Pipe Supports:			
Wind Load: 100 MPH (SBCC I)		Seismic: ZONE 1 (ANSI)	
Wt. Empty	lb.	Wt. Full of Water	lb.

MATERIALS

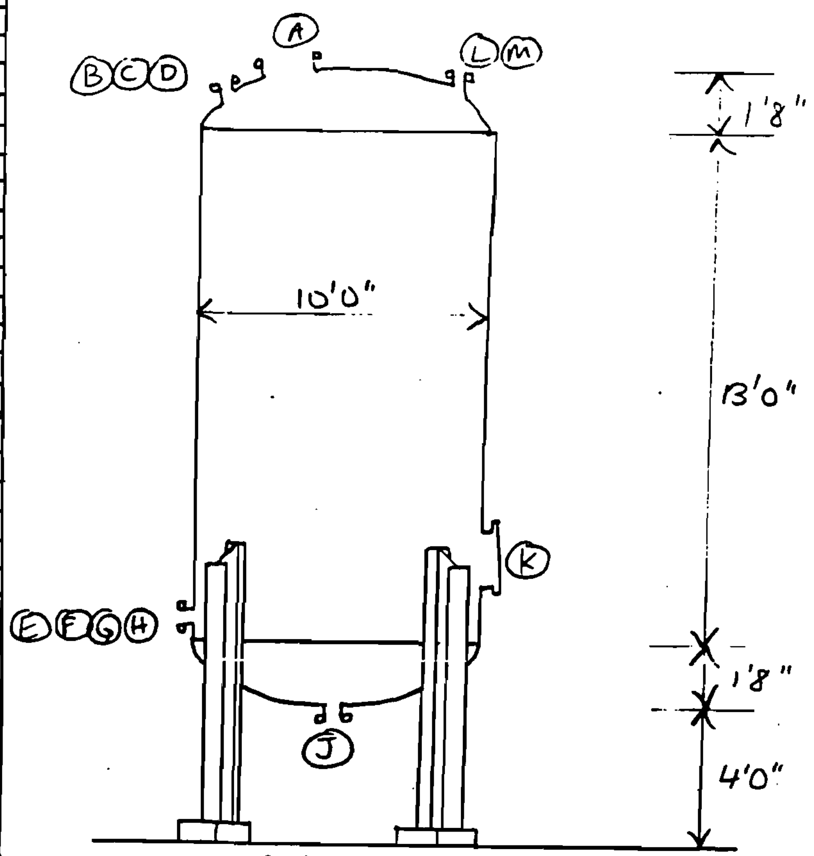
Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	5/16 in.	FRP	ASTM D 3299
Heads	5/16 in.	FRP	ASTM D 3299
Lining	in.		
	in.		
	in.		
Nozzle Necks		FRP	
Flanges		FRP	
Coupling			
M.H. Cover		FRP	
Supports		CS	A36
Bolts/Studs			
Nuts			
Gaskets			

NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
MANWAY/PSV	A	1	24"	150#		FLG
VENT	B	1	6"	↓		↓
LSHH	C	1	2"			
LEVEL TRANSM.	D	1	1"			
-"-	E	1	4"			
TEMPERATURE	F	1	2"			
SAMPLE POINT	G	1	1"			
SPARE	H	1	4"			
PUMP SUCTION	J	1	4"			
MANWAY	K	1	24"			
SPARE	L	1	4"			
FILL	M	1	4"	↓		↓
	N					
	P					
	Q					
	R					

Nozzle to be Plugged or Blinded

TANK SKETCH



Only two of four legs shown for purpose of clarity.

Note: All dimensions are approximate

WES 15-0186

IWES

Waste Receiving Bin
DATA SHEET

PROJECT FFPI - 8813

SPEC. NO.
SHEET 1 OF 1
PROJ. NO.: 8813

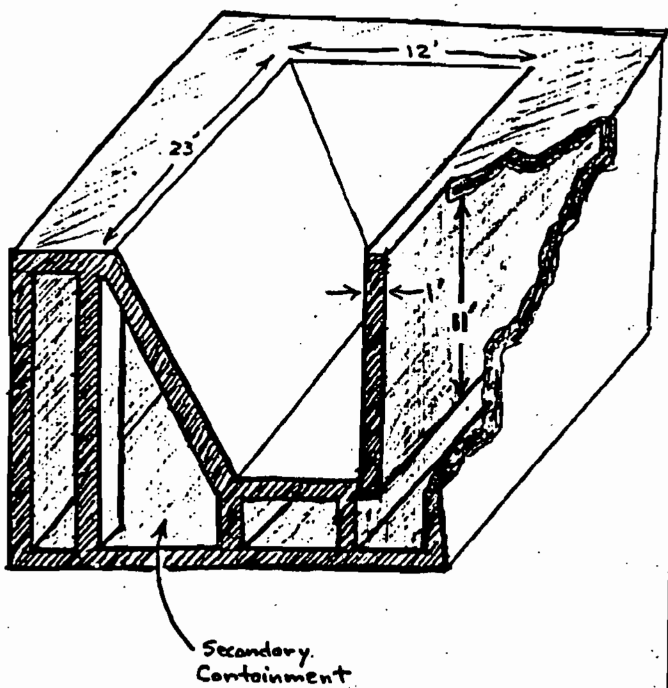
1	Equipment No.:	T-54
2	Equipment Name:	Waste Receiving Bin
3	Equipment Service:	Hold dry mixture
4	of incinerator ash, cement, flyash	
5	and other dry solids.	
6		
7		
8		
9		
10	PERFORMANCE	
11	Operating Pressure psig	Atmospheric
12	Operating Temperature deg. F	Ambient
13	Density lb/cu.ft.	120
14	Contents Lethal	(NO) YES
15	Design Pressure psig	Atmospheric
16	Design Temperature deg. F	30-99
17	Volume (WORKING) cu.ft.	945
18		
19	Hydrostatic Test psig	NO
20	Shell Thickness in.	12
21	Base Thickness in.	12
22		
23		
24	CONSTRUCTION	
25	Insulation in.	NO
26	Fireproofing	(NO) YES
27	Sandblasting	(NO) YES
28	Paint/Sealer	Concrete Sealer
29	Wind Load mph	NA
30	Seismic Zone	1
31	Design Code	ACI-318
32	MATERIALS OF CONSTRUCTION	
33	Walls	Reinforced Concrete
34	Base	Reinforced Concrete
35		
36		
37	NOZZLE SCHEDULE	

	Description	Mark	Size	Rating	Type
38	Description	Mark	Size	Rating	Type
39	None	A			
40	↓	B			
41	↓	C			
42	↓	D			
43	↓				
44					

SKETCH

Top of tank completely enclosed by sheet metal siding, roofing and roll-up doors.

Front wall not shown. Cut-away view.



Note: All dimensions are approximate

REMARKS

REVISION NO.	C-2				
PREPARED BY/DATE	JAO 8/3/90				
CHECKED BY/DATE	RWL 8/27/90				
APPROVED BY/DATE	PTK 9/27/90				

IWES-001 SHEET 1 OF 1

Waste Energy Systems

BEST AVAILABLE COPY

SPECIFICATION NO. ______
EQUIPMENT NO. T-62

REV: A
BY: JAO
CHK'D BY: RWG

JECT NAME: FFPI
JIPMENT NAME/APPLICATION: FILTRATE BUFFER TANK - INORGANIC WASTE
WES PROJECT No. 8813

DESIGN DATA

Operating Pressure	psig	-0.15 to +0.30
Operating Temperature	°F	32° to 125
Liquid Specific Gravity		1.10
Contents Lethal		~~Yes~~ No
Design Pressure	psig	-0.30 to +0.45
Design Temperature	°F	180°
DESIGN pH		8-12
CAPACITY		240,000 gal
Hydrostatic Test	psig	
Shell / Heads Corr. Allow.	in.	
Shell / Heads Joint Eff.	%	
Code: NBS-PS 15-69		Stamp ~~Yes~~ No
Radiograph:		Stress Relieve:
Type Supports:		
Insulation:		
Fireproofing:		
Sandblast:		Paint:
Manhole ☐ Hinged	☐ Davited	☐ Other:
Platform Clips:	Ladder Clips:	Insul. Rings:
Pipe Supports:		
Wind Load: 100 MPH (SBCCI)		Seismic: ZONE 1 (ANSI)
Wt. Empty lb.		Wt. Full of Water lb.

MATERIALS

Item	Thickness	Mat'l Class	Mat'l-Minimum Quality
Shell	* in.	FRP	ASTM D3299
Heads	in.	FRP	ASTM D3299
Lining	in.		
	in.		
	in.		
Nozzle Necks		FRP	
Flanges		FRP	
Coupling			
M.H. Cover		FRP	
Supports		CS	A 36
Bolts/Studs			
Nuts			
Gaskets			

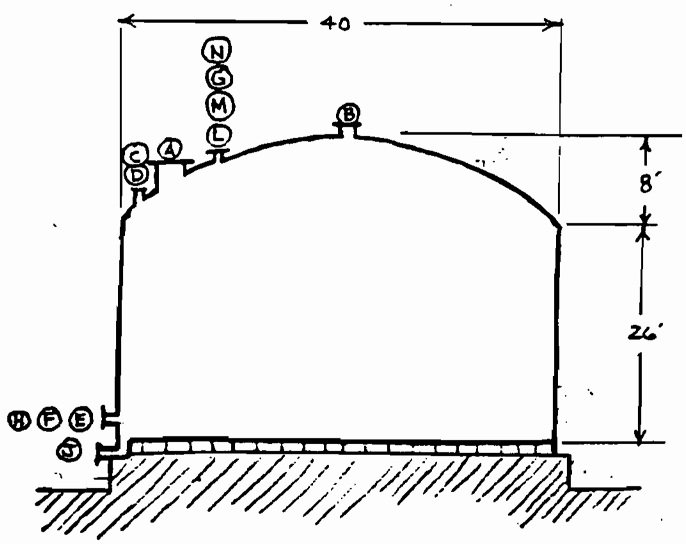
NOZZLE SCHEDULE

Service	Mark	No.	Size	Rating	Face	Type
MANWAY/PSV	A	1	24"	150 #		FLG
VENT	B	1	3"	↓		↓
LSHH	C	1	2"			
LEVEL TRANSM.	D	1	4"			
-"-	E	1	4"			
TEMPERATURE	F	1	2"			
FILL	G	1				
SPARE	H	1	4"			
PUMP SUCTION	J	1	4"			
	K					
SPARE	L	1	4"			
RECYCLE	M	1	4"			
PRESSURE	N		2"			
	P					
	Q					
	R					

Nozzle to be Plugged or Blinded

WES 15-0186

TANK SKETCH



* Shell Thickness 1.2" Tapering to 3/8"

Note: All dimensions are approximate

CALGON CARBON

ventsorb®

for INDUSTRIAL AIR PURIFICATION

Carbon canisters control odors "at source"

Effective means of air pollution control

BERT HARTELIUS
Manager of Environmental Control
Merck Chemical Manufacturing Division
Merck & Co., Inc.
Rahway, New Jersey
with CP Staff

New Solutions to Plant Problems

Problem: Until a few years ago, the Merck Chemical Manufacturing Division plant in Rahway, New Jersey, experienced severe operational and cost problems related to the use of a catalytic incinerator for control of highly odorous and some hazardous chemicals. This plant, which is a major manufacturing arm of Merck & Co., Inc., produces more than 50 bulk chemical products for use in pharmaceutical and pure drug applications.

Solution: To alleviate this problem, the plant permanently closed down the incineration operation and installed a total ventilation system which uses carbon adsorption canisters. The carbon adsorption canisters now control obnoxious hydrogen sulfide and mercaptan odors (both detectable at concentrations of less than one part per billion) emanating from intermediate sulfur compounds used in the production of thiabendazole (TBZ). In addition, the canister units are used to trap vapors from 50-gal drums of monochloroacetone, which is also used in the TBZ manufacturing process. The canisters, in combination with condensers, ammonia recovery systems, and scrubbers, consistently achieve emission levels acceptable to both plant and New Jersey Department of Environmental Protection specifications.

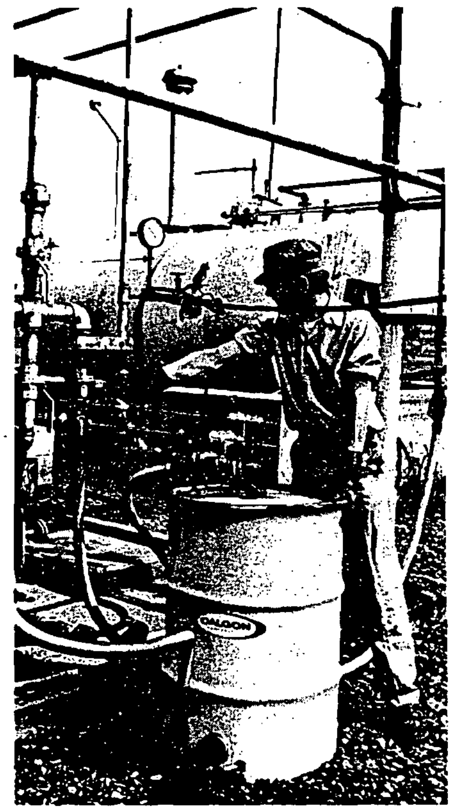
To prevent the escape of vapors while filling the 50-gal drums with monochloroacetone, a 150 cfm blower directs air streams into a single canister unit at ambient temperature. The canister installation has reduced contaminant levels from 0.16 to less than 0.01 lb/hr.

Once a week, plant personnel do a smell test. If a strong odor is detectable, the carbon canister is replaced. The units normally last about two months on this and other TBZ intermediate compound operations.

The carbon adsorption canisters are prefabricated, granular activated carbon filters that include all of the essential elements of a full-scale adsorption system: vessels, support media, activated carbon, and inlet distribution nozzle. Each filter contains approximately 150 lb of a 4 x 10 mesh, vapor-phase granular carbon supported on an eight inch deep gravel underbed. A two-inch coupling provided near the base of the canister serves as an inlet nozzle. A two-inch outlet centered in the canister cover allows easy installation of an outlet vent.

Results: The key benefit of the carbon adsorption system is that it makes possible "at-source" control of vapors before they invade the plant's ventilation system. The units are an inexpensive and effective method of air pollution control, are simple to install, keep maintenance and replacement costs down and use little energy while in operation. ■

Ventsorb® carbon adsorption canisters are manufactured by Calgon Corp., Calgon Center, P.O. Box 1346, Pittsburgh, PA 15230.



Granular activated carbon canister removes highly odorous organic mercaptans present in the thiabendazole waste stream at the Rahway, N.J. plant.

reprinted from June 1980
CHEMICAL PROCESSING.
A PUTMAN PUBLICATION

CALGON
CALGON CARBON CORPORATION

HIGH FLOW VENTSORB

ACTIVATED CARBON PRODUCT BULLETIN

description

Calgon Carbon's High Flow VentSorb® odor control unit is a unique concept developed by Calgon Carbon Corporation to protect against noxious, unhealthy, and unpleasant odors emanating from small volume emissions from a variety of sources within sewage treatment plants.

The odors emitted from localized areas usually contain a complex mixture of hydrogen sulfide, mercaptans, and organic compounds which are generally harmless in nature, but can be olfactive at levels as low as one-half part per billion. As a result, even small emissions can create unnecessary problems both within the plant and within the surrounding community.

The High Flow VentSorb is a reusable, modular, prefabricated canister containing 225 pounds of IVP* Granular Activated Carbon that has more than twice the capacity for H_2S as an equal quantity of a standard vapor phase carbon. It includes all of the essential items found in a large-scale adsorption system--vessel, activated carbon, inlet connection, and an outlet connection for the purified air stream.

The High Flow VentSorb was designed by Calgon Carbon Corporation for purification of air streams having flows up to 425 cfm and with relatively low organic concentrations.

features and benefits

- **Easy To Install**--Place the High Flow VentSorb modular canister on a level surface, indoors or outdoors, near the source of the emission to be controlled. Connect a 6-inch flexible hose or pipe from the system to the inlet nozzle at the base of the High Flow VentSorb. Then connect the 6-inch outlet nozzle centered in the removable canister lid to the system outlet vent. A U-shaped vent line that will serve as a rain guard is recommended.
- **Reusable Modular Prefabricated Canisters**--When the carbon in the High Flow VentSorb is saturated and can no longer remove additional pollutants, it can be easily replaced. Unhook the unit from service, remove the twist off cover, and dispose of the saturated carbon--in accordance with environmental regulations. Then install a new charge of virgin IVP carbon and return the unit to service.
- **Replacement Carbon**--Two hundred twenty-five pound drums of IVP carbon are available from Calgon Carbon. To ensure replacement carbon is readily available when breakthrough occurs, one or more spare drums should be available for each installation.
- **Non-Corrosive**--All High Flow VentSorb components are fabricated from polypropylene resins that have a proven reliability for this type of service.
- **Effective In Treating Simple Or Complex Mixtures Of Contaminants**-The IVP granular activated carbon provides simultaneous protection against a wide variety of emissions including hydrogen sulfide, mercaptan, and many other organic chemicals.
- **Continuous Treatment**--The High Flow VentSorb works 24 hours per day to remove contaminants from air emissions regardless of fluctuations in the flow of the air stream.
- **Low Cost System**--The High Flow VentSorb contains no moving parts. Its simplicity helps to keep costs to a minimum.

*U.S. Patent No. 4,072,479

- **Virtually No Operator Attention Required**--An occasional check of the treated air quality is all that is required.
- **Flexibility To Meet A Variety Of Needs**--A High Flow VentSorb unit requires relatively little space. Where necessary, more than one unit can be installed easily at different locations on a plant site. Additional units can be installed in series or in parallel configurations.

pressure drop characteristics

Pressure drop through a High Flow VentSorb is a function of the odor laden air flow as shown in the graph. A High Flow VentSorb can handle up to 400 cfm at a pressure drop of less than 7 inches of water column. If higher flows or lower pressure drops are needed, multiple canisters may be installed in parallel operation. The High Flow VentSorb modular canister is rated for atmospheric pressure.

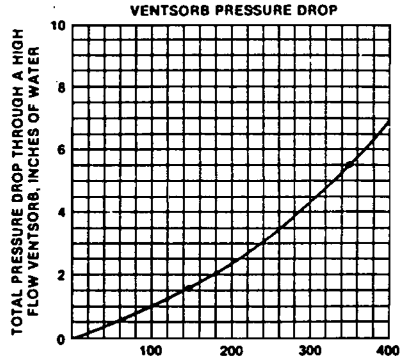


FIGURE 1

life cycle characteristics

Figure 2 is a graph projecting the theoretical life of a High Flow VentSorb with IVP at various H_2S levels and a flow rate of 300 scfm. Actual life will depend on the type and concentration of contaminants as well as temperature, humidity, and airflow. Contact your Calgon Carbon representative for additional infromation.

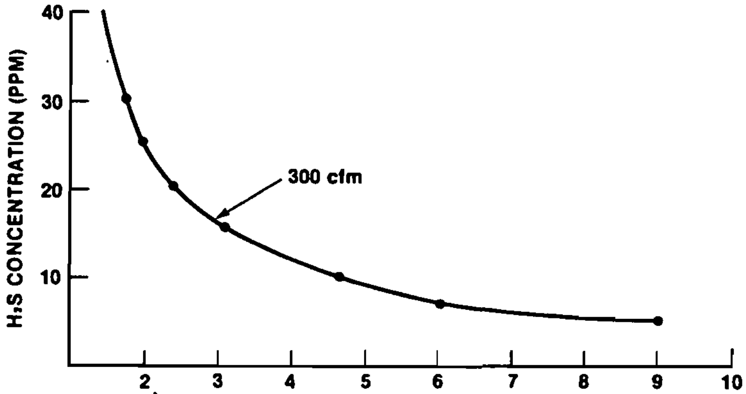


FIGURE 2

commercial information

Shipping Point:	Pittsburgh, Pennsylvania
Packaging:	Modular Canister— 45 Lbs. Gross Weight
	Activated Carbon— Packaged In 55-Gallon Leverpak Drums; 225 Lbs. Net, 242 Lbs. Gross Weight
Replacement Carbon:	Packed In 55-Gallon Leverpak Drums; 225 Lbs. Net, 242 Lbs. Gross Weight

precautions

Calgon Carbon's type IVP activated carbon can liberate heat by reacting chemically with oxygen to form carbon dioxide. This potential is enhanced by an impregnated material which causes a catalytic reaction. Because heat is evolved, the carbon must not be confined without operative fans which are necessary to provide air flows required for heat dissipation. Inoperative fans permit formation of convective air drafts within the vessel that support this slow chemical reaction but which are insufficient for heat removal. In cases where there is insufficient air supply or where disrupted air service occurs, the chemical reaction can be prevented by sealing the vessel and thereby restricting contact between air and the carbon. Please call your local Calgon Carbon Representative for any clarification of the above.

Information concerning human and environmental exposure may be reviewed on the Material Safety Data Sheet and label for this product.

CALGON

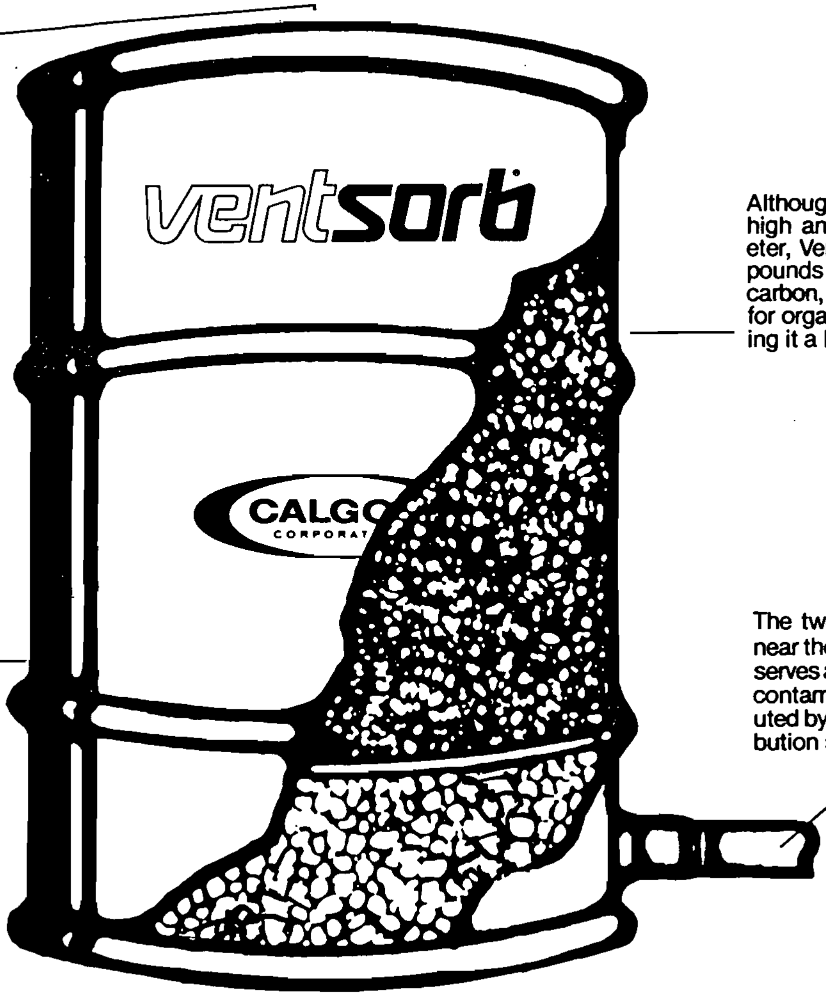
CALGON CARBON CORPORATION
P.O. BOX 717, PITTSBURGH, PA. 15230-0717

Printed in U.S.A.

VentSorb® is the first compact granular activated carbon filter that contains all the essentials of a full-scale adsorption system.

VentSorb Applications:

- **Emission Control for Toxic, Odorous and Volatile Organic Compounds (VOC)**
  - Storage Tank Vents
  - Drum Loading/Unloading Area Ventilation
  - API Separator Vents
  - Wastewater Treatment Plant Vents
  - Laboratory Vents
- **Pilot Studies for Demonstrating Feasibility of Adsorption**
- **Corrosion Control for Instrument and Electrical Control Panels**



VentSorb— the unique, low-cost approach to air purification — should be part of your pollution control system.

Safety Information:

Some chemical compounds in air in contact with activated carbon may oxidize, decompose or polymerize under certain conditions. This may result in temperature increases sufficient to cause ignition of the adsorbed materials and the carbon bed. For this reason, VentSorb should not be used on organic streams which have peroxide-forming tendencies, such as methyl ethyl ketone.

CALGON CORPORATION

ACTIVATED CARBON DIVISION
CALGON CORPORATION

SUBSIDIARY OF MERCK & CO., INC.

Important VentSorb® Application Information

How to estimate VentSorb carbon filter life:

This table lists the theoretical adsorption capacities for several compounds. The adsorption capacity for nonpolar organics increases with the boiling point, molecular weight and concentration of the air contaminant. Estimate the life of a VentSorb unit for other organic compounds by matching them with compounds of similar boiling point and molecular weight in this table. Low molecular weight (less than 50) and/or high polar compounds such as formaldehyde, methane, ethanol, etc., will not be readily adsorbed at low concentrations.

Theoretical VentSorb Capacities

	Boiling Point °C	Molecular Weight	Theoretical VentSorb Capacity, Lb. Adsorbed/VentSorb*		
			10 ppm	100 ppm	1,000 ppm
Acrylonitrile	77.3	53.1	3	9	21
Benzene	80.1	78.1	20	28	42
n-Butane	-0.5	58.1	2	5	10
Carbon Tetrachloride	76.8	153.8	30	50	74
Dichloroethylene	37.0	97.0	10	21	40
Methylene Chloride	40.2	84.9	2	4	14
Freon 115	-37.7	154.5	2	6	11
n-Hexane	68.7	86.2	9	20	28
Styrene	145.2	104.1	39	52	63
Toluene	110.6	92.1	31	40	51
Trichloroethylene	87.2	131.4	28	50	72
Vinyl Chloride	-13.9	62.5	1	2	4

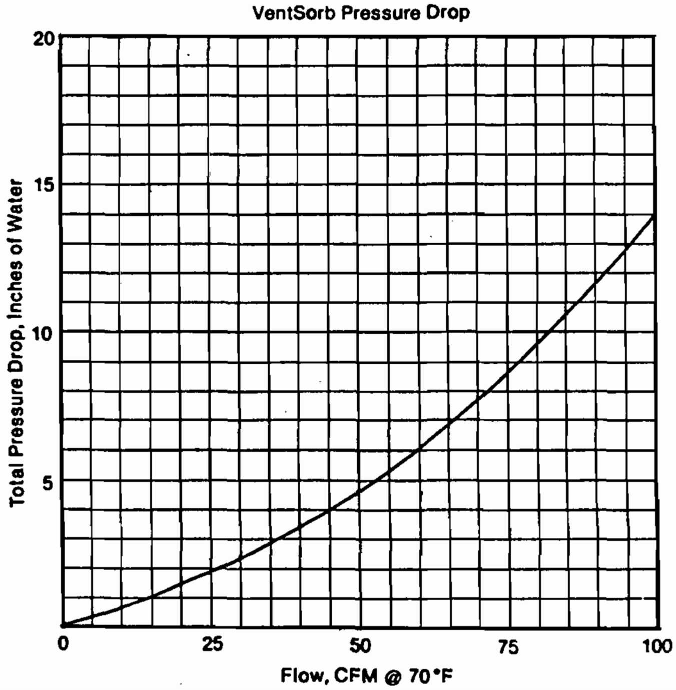
* Theoretical capacity based on 70°F, 15 psig and 150 pounds of carbon using isotherm data for Type BPL carbon.

NOTE: The standard VentSorb unit contains 150 pounds of BPL carbon. When removing H_2S and mercaptans from moist air streams, you'll achieve the greatest efficiency by using a VentSorb unit which contains specially impregnated Type IVP carbon. An IVP VentSorb can remove up to 30 pounds of H_2S and 15 pounds of methyl mercaptan. If you need VentSorb units with Type IVP carbon, please specify when ordering your units.

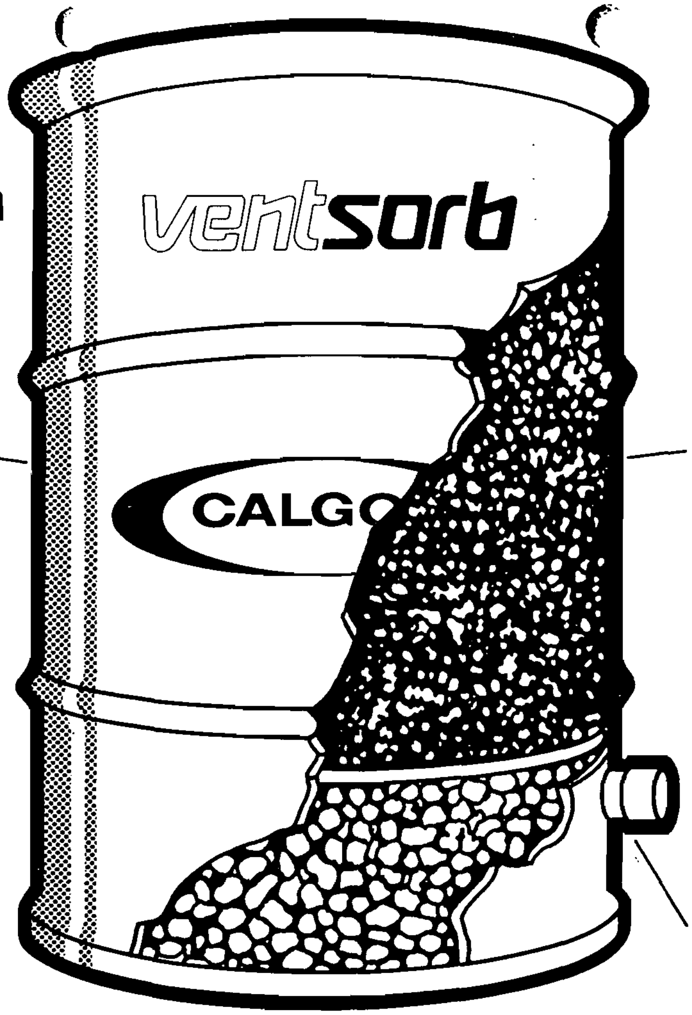
How to determine pressure drop:

Pressure drop through a VentSorb unit is a function of the process air flow as shown in the graph to the right. A VentSorb canister can handle up to 100 CFM at a pressure drop of less than 15 inches water column. If higher flows or lower pressure drop is needed, multiple canisters may be installed in parallel operation. The maximum canister pressure should not exceed 4 psig.

VentSorb Pressure Drop



Materials of Construction



The VentSorb canister is a specially designed, full open-head, steel canister. It includes a removable cover and bolt-type closing ring with a polyclad cellulose gasket. The interior of the canister is lined with two coats of a heat-cured, epoxy-modified, phenolic material for superior corrosion resistance. This lining is suitable for use at operating temperatures up to 350° F.

A two-inch outlet centered in the canister cover allows easy installation of an outlet vent. A U-shaped vent line that will serve as a rain guard is recommended.

The standard VentSorb unit contains approximately 150 pounds of high quality, broad-spectrum Type BPL granular activated carbon, supported on an eight-inch deep gravel underbed.

If your problem includes hydrogen sulfide or methyl mercaptan removal from moist air, you may want to consider a VentSorb unit containing Type IVP granular activated carbon which is especially effective for this application.

A two-inch IPT coupling provided near the base of the canister serves as an inlet nozzle.

Easy to Install and Use

Installation of a VentSorb unit is relatively simple. Place the VentSorb canister on a level surface near the vent to be controlled. Then connect a 2-inch flexible hose or pipe from the vent to the standard-thread inlet nozzle at the base of the canister.

If volatile organics are present, a flame arrestor should be attached to the VentSorb unit.

Since each VentSorb can handle air flows up to 100 CFM, only one unit normally need be in service on a vent at any time. Larger flows can be accommodated by employing additional units in parallel operation.

Once installed, VentSorb is designed to provide continuous control of vented emissions with virtually no attention.

Using the positive pressure inside the unit being vented, contaminated air passes up through the canister where the objectionable vapors are trapped and stored in the carbon, allowing a purified air stream to vent through the top of the canister into the atmosphere. In most cases, the pressure or surges of pressure within the space being vented is sufficient to overcome pressure drop across the carbon bed and a blower is not required.

VentSorb will continue to remove vapors until the carbon in the canister becomes saturated.

Replacing Spent Filters

The useful life of a VentSorb unit will vary from one installation to another depending upon the type and amount of vapors to which the carbon is exposed. In some plants, VentSorb units have remained effective up to eight months.

When the carbon in your VentSorb unit is saturated and can no longer remove additional pollutants, it can be replaced easily. Unhook the unit, seal it and dispose of it in accordance with environmental regulations for similar process solid wastes. Then install a new VentSorb unit.

To assure that replacement units are available immediately when needed, one or more spare units should be located at each installation site.

When using Type IVP activated carbon you should know that the carbon can liberate heat by reacting chemically with oxygen to form carbon dioxide. This potential is enhanced by an impregnated material which causes a catalytic reaction. Because heat is evolved, the carbon must not be confined without operative fans which are necessary to provide air flows required for heat dissipation. Inoperative fans permit formation of convective air drafts within the vessel that support this slow chemical reaction but which are insufficient for heat removal. In cases where there is insufficient air supply or where disrupted air service occurs, the chemical reaction can be prevented by sealing the vessel and thereby restricting contact between air and the carbon. Please call your local Calgon Carbon Representative for any clarification of the above.

Benefits and Advantages

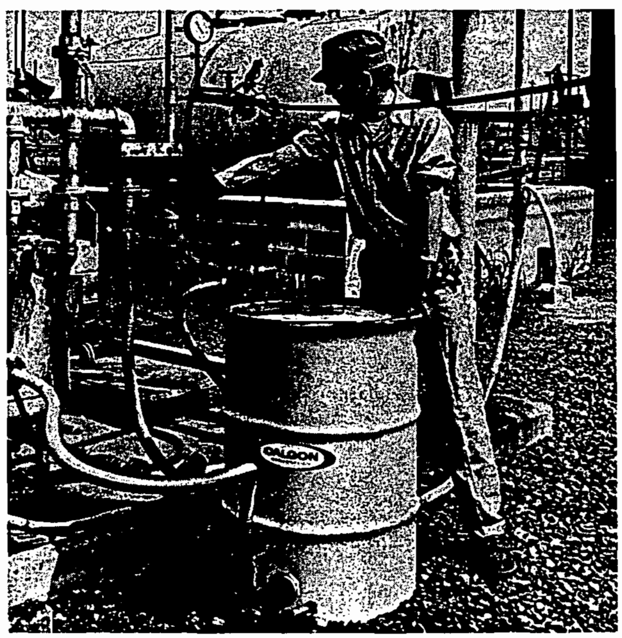
There are many significant benefits and advantages to using VentSorb to control vented emissions:

- Effective in treating a wide variety of contaminants—The granular activated carbon provides simultaneous protection against a wide variety of vented emissions including most odors, amines, arsine, hydrogen sulfide, sulfur dioxide, mercaptan, aldehydes, halogens, hydrocarbons, chlorinated hydrocarbons, monomers, organic decomposition products, oil vapors, solvents and numerous other organic gases and vapors.
- Continuous treatment—VentSorb works 24 hours per day to clean up air emissions regardless of fluctuations in the air stream.

Typical Applications

VentSorb is being used now in chemical, petrochemical, food, pulp and paper, and sewage treatment plants, and in numerous other industries. In these applications, it has proven to be an effective and economical means for providing continuous control of vented emissions without the need for complicated process equipment. Here are some typical applications:

- Storage tank vents.
- Reactor vents.
- API separator vents.
- Sludge thickener tanks at sewage treatment plants.
- Sewer gas vents at chemical and municipal waste treatment plants.
- Wastewater holding tanks at chemical plants.
- Vents from hood exhausts of chemical laboratories.
- Low-cost system—The VentSorb system contains no moving parts. Its relative simplicity helps to keep costs to a minimum.
- Easy to install—VentSorb is prefabricated and pre-piped. Installation can be performed easily by plant personnel.
- Virtually no operator attention required—An occasional check of the treated emission quality is the extent of the need for personnel time.
- Flexibility to meet a variety of needs—A VentSorb unit requires relatively little space. Where necessary, more than one unit can be installed easily at different locations on a large plant site. Additional units can be installed in series, or in parallel, if required.



Obnoxious hydrogen sulfide and mercaptan odors from intermediate sulfur compounds are removed from the air at this chemical plant with prefabricated VentSorb units (foreground). These easy-to-use units control unwanted vapors at the point of origin before they permeate the plant ventilation system.

VentSorb is a unique concept in air purification developed by Calgon Carbon Corporation to protect air quality against toxic, unhealthy and unpleasant air streams. It offers an economical way to control vapors vented from storage tanks, reactor vessels and other process equipment, laboratory exhaust hoods, and similar sources of small volume emissions.

The air and gas streams exhausted from these vents usually contain noxious organic materials that should not be emitted into work areas or into the atmosphere—odors, toxic vapors, irritants and corrosive gases, among others. Increasingly, it is a violation of air pollution laws and occupational safety regulations to vent such gas streams without removing these contaminants.

VentSorb is a modular, prefabricated canister containing granular activated carbon. It includes all of the essential items found on a large-scale adsorption system—vessel, activated carbon, inlet connection and distributor leading to the carbon, and an outlet connection for the purified gas stream.

VentSorb was designed by Calgon Carbon Corporation for purification of air emitted from vents having flows generally less than 300 CFM and relatively low in organic loading.

Table 1 is a partial list of organic contaminants amenable to adsorption on activated carbon. The useful life of a VentSorb unit in a particular installation will depend upon the type, concentration, and volume of organic contaminants and will therefore vary with each application. The capacities listed in Table 1 are theoretical and can be used as a general guide in estimating the life. Actual life can only be determined through on-stream testing.

The life of a VentSorb for organic compounds not listed in Table 1 can be estimated by finding in Table 1 a material of similar boiling point and molecular weight. Generally, adsorption capacity increases with the boiling point, molecular weight, and concentration of air contaminants. Low molecular weight (less than 50) and/or highly polar compounds such as formaldehyde, methane, and ethanol, will not be readily adsorbed at low concentrations.

Table 1

Theoretical VentSorb Capacities

			Theoretical VentSorb Capacity, Lb. Adsorbed/VentSorb*		
	Boiling Point °C	Molecular Weight	10 ppm	100 ppm	1,000 ppm
Acrylonitrile	77.3	53.1	3	9	21
Benzene	80.1	78.1	20	28	42
n-Butane	- 0.5	58.1	2	5	10
Carbon Tetrachloride	76.8	153.8	30	50	74
Dichloroethylene	37.0	97.0	10	21	40
Methylene Chloride	40.2	84.9	2	4	14
Freon 115	- 37.7	154.5	2	6	11
n-Hexane	68.7	86.2	9	20	28
Styrene	145.2	104.1	39	52	63
Toluene	110.6	92.1	31	40	51
Trichloroethylene	87.2	131.4	28	50	72
Vinyl Chloride	- 13.9	62.5	1	2	4

*Theoretical capacity based on 70° F, atmospheric pressure and 150 pounds of carbon using isotherm data for Type BPL carbon.

Note: The standard VentSorb unit contains 150 pounds of BPL carbon. When removing H_2S and mercaptans from moist air streams, you'll achieve the greatest efficiency by using a VentSorb unit which contains specially impregnated Type IVP carbon. An IVP VentSorb can remove up to 30 pounds of H_2S and 15 pounds of methyl mercaptan. If you need VentSorb units with Type IVP carbon, please specify when ordering your units.

Proven in Use

The successful operation of VentSorb in a variety of applications has proven the effectiveness and economy of these units. Following are examples which demonstrate how VentSorb helped meet the needs of some users.

Storage Tank Vents—VentSorb is widely used to control evaporative losses vented from storage tanks containing a wide variety of volatile hydrocarbons and organics. These vapors are emitted during tank filling and emptying and on an almost continuous basis as the result of tank breathing.

In a somewhat different approach, a glycerine manufacturer is using VentSorb to purify air that is drawn into storage tanks during pumping-out operations. VentSorb removes odorants and other impurities and prevents contamination of the product glycerine. It provides six-months service in this application before replacement is needed.

A similar approach is being used on pinene storage tanks.

Other applications are for storage tanks containing materials with extremely high vapor pressure at ambient conditions which are more efficiently controlled with refrigeration-compression systems. Examples of these materials are methanol, acrylonitrile and methylene chloride. VentSorb units are being used as a back-up to remove the last traces of objectionable odors from the tanks.

Reactor Vents—After a reaction is completed in a closed system, the reactor vessel is often vented to the atmosphere before its contents are discharged. VentSorb is being used in more and more cases to control the vented gases which contain unreacted starting materials, by-products, and other odorous or toxic substances.

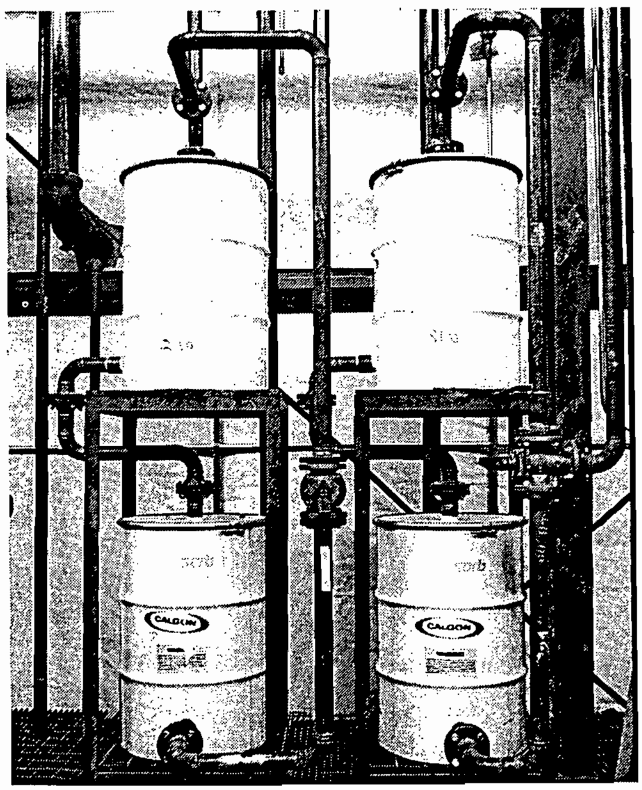
A pesticide manufacturer has installed VentSorb on five reactor vessels to control trace amounts of methylamine and diethylamine which are by-products of a caustic scrubbing operation. These vapors have an odor threshold level of 0.02 ppm. Each VentSorb handles a 30 CFM stream containing 15 ppm of amine vapors. The units provide over three months service in this application.

VentSorb units are also used in pesticide manufacturing to control off-gases from reactor vent condensers. While the bulk of the amines are removed in the condensers, some higher molecular weight amines and hydrogen sulfide pass through, creating serious odor problems. VentSorb is used following the condensers to eliminate the odorous emissions. The units are handling air flows ranging from 30 to 75 CFM and last up to six months in this application.

The unreacted monomers discharged during the venting of batch polymerization reactors may result in serious odor or toxicity problems even at very low concentrations. This is particularly true of such monomers as methyl methacrylate, acrylonitrile, and vinyl chloride. While the bulk of the vented monomer vapors are usually removed in a condenser, more and more often VentSorb is being installed after vent condensers to remove the last traces of these materials.

At one installation, where the stream leaving the condenser still contains approximately 15 ppm of ethyl acrylate, two VentSorb units are operated in series. When odor is noticed from the up-stream filter, it is replaced by the stand-by filter. Normal cycle time is approximately three months.

VentSorb is also being used on reactors where toxic vapors are removed by pulling a vacuum on the vessels. VentSorb units are installed either on the vacuum side or exhaust end of the vacuum pump.



Four VentSorb units at a chemical plant are installed to operate in series and in parallel. More than 25 odorous and/or toxic vapors are controlled by 80 VentSorb units at this plant.

API Separator Vents—Odorous hydrocarbons, mercaptans, and hydrogen sulfide are emitted from settling basins where oil is separated from wastewater that is discharged in condensate streams and from relief valves, blowdown systems, and drain lines. To comply with air pollution control regulations, these API Separators are covered and vented. VentSorb is being used to control the odorous emissions which are vented.

At one location, emissions from a covered separator are vented through PVC piping into a PVC header which feeds two VentSorb units operating in parallel. A 3/4 h.p. blower pulls the stream through the filters, each of which handles 100 CFM. Two additional Vent Sorb units are kept on standby.

Warning Under certain conditions some chemical compounds in air may oxidize, decompose or polymerize when contacted with activated carbon. For this reason, VentSorb should not be used with methyl ethyl ketone. If the reaction of activated carbon is not known, appropriate tests should be performed before putting VentSorb into service.

Calgon Carbon recommends that suitable flame arresting devices be installed as an added safety precaution.

For information regarding incidents involving human and environmental exposure, call (412) 787-6700 and ask for the Regulatory and Trade Affairs Department.

There are no warranties either expressed or implied or any warranty of merchantability or fitness for a particular purpose associated with the sale of this product.

How to Determine Pressure Drop:

Pressure drop through a VentSorb unit is a function of the process air flow as shown in the graph. A VentSorb canister can handle up to 100 CFM at a pressure drop of less than 15 inches water column. If higher flows or lower pressure drop is needed, multiple canisters may be installed in parallel operation. The maximum canister pressure should not exceed 4 psig.

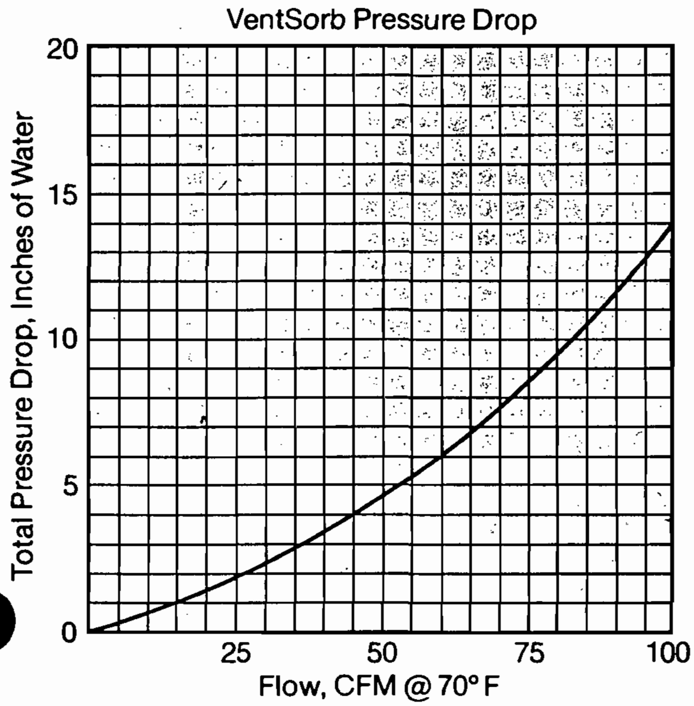
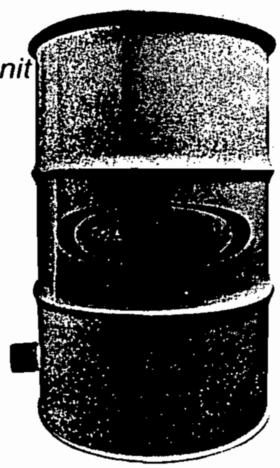


Figure 1

VentSorb Air Purification Unit



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CALGON

CALGON CARBON CORPORATION

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APPENDIX D-4

Add to appendix

COUNTER-CURRENT FLOW SCRUBBERS

COUNTER—CURRENT SCRUBBERS

Ceilcote vertical counter-current packed scrubbers provide high collection efficiencies for noxious gas absorption and liquid entrainment removal. In counter-current scrubbers, the contaminated air moves upward in direct opposition to the scrubbing liquid, as the liquid moves down through the packed bed. These highly versatile scrubbers can remove a variety of both corrosive gases and liquid particulates from an air stream containing either a single pollutant or a combination of different pollutants.

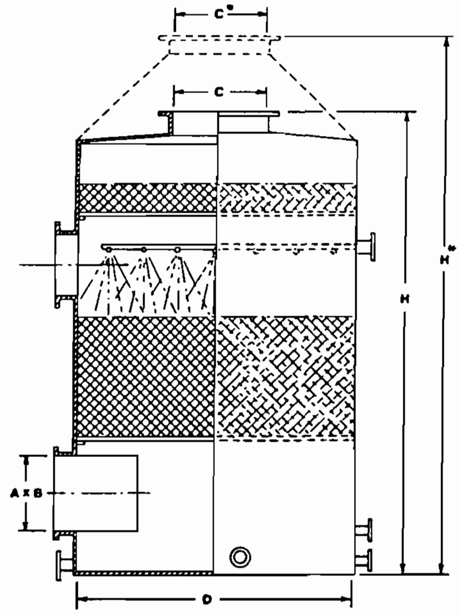
Highly soluble gases are transferred from the air stream into the scrubbing water by diffusion and physical absorption. Medium or low solubility gases can be removed by the mechanism of physical absorption followed by chemical reaction.

Two standardized counter-current scrubber series, designated SPT and RPT, have been pre-engineered to assure quick delivery and lower cost. This is possible since design, engineering and drafting times are minimized.

The high efficiency Model SPT scrubbers will handle a majority of counter-current applications routinely achieving 99% collection efficiency for gas absorption and liquid entraiment separation. For less stringent requirements, the medium efficiency Model RPT scrubbers with less packing depth and lower overall height can offer a lower cost solution to some problems. Refer to Bulletin 12-2 for additional information.

If the requirements of a scrubbing problem cannot be met by standard SPT-RPT scrubbers because of process conditions or the nature of contaminant, Ceilcote can custom design a counter-current scrubber to handle the specific application.

For high efficiency absorption of medium or low solubility gases, for example, columns have been designed containing a depth of from 6 to 30 feet or more of Tellerette Tower Packing.



For removal of liquid entrainment from the gas stream prior to discharge, Ceilcote counter-current scrubbers normally employ a 9" bed of 1" Tellerette Tower Packing. This provides a removal efficiency of 98% or more by particle count for liquid particulates 5 microns and larger.

Model No.	Capacity SCFM	Liquid Rate GPM	Diameter D	Overall Height H	Overall Height H*	Inlet Size A X B	Outlet Diameter C	Outlet Diameter C*	Shipping Weight (Lbs.)	Operating Weight (Lbs.)
SPT-05	330	4	1'-0"	11'-9"	—	6"	6"	—	250	375
SPT-13	750	9	1'-6"	12'-0"	—	10"	10"	—	375	625
SPT-26	1,550	19	2'-0"	12'-9"	—	14"	14"	—	500	975
SPT-43	2,500	30	2'-6"	13'-9"	—	16"	16"	—	675	1,400
SPT-60	3,500	43	3'-0"	13'-9"	—	20"	20"	—	850	1,900
SPT-82	4,800	58	3'-6"	14'-3"	—	24"	24"	—	1,075	2,450
SPT-107	6,300	75	4'-0"	14'-9"	—	26"	26"	—	1,300	3,100
SPT-136	8,000	95	4'-6"	—	15'-3"	30"	—	24"	1,575	3,900
SPT-170	10,000	118	5'-0"	—	16'-0"	32"	—	26"	1,850	4,700
SPT-204	12,000	143	5'-6"	—	16'-6"	36"	—	28"	2,150	5,600
SPT-241	14,200	170	6'-0"	—	17'-3"	42"	—	30"	2,450	6,500
SPT-328	19,300	230	7'-0"	—	16'-6"	2' X 6'	—	36"	3,050	8,650
SPT-425	25,000	300	8'-0"	—	17'-3"	2'-6" X 6'	—	42"	3,550	10,800
SPT-544	32,000	382	9'-0"	—	17'-9"	2'-6" X 8'	—	48"	4,300	13,500
SPT-668	39,300	470	10'-0"	—	18'-9"	3' X 8'	—	48"	5,000	16,500
SPT-808	47,500	570	11'-0"	—	19'-3"	3' X 10'	—	54"	5,900	19,700
SPT-961	56,500	678	12'-0"	—	20'-9"	3'-6" X 10'	—	60"	7,000	23,300

NOTES:

1 Overall height of RPT series scrubbers is 1'-6" less than SPT series.

2 Pressure drop for SPT series scrubbers is about 2½" w.c. when operating at rated capacity.

3 Dimensions for custom design scrubbers will vary to meet specific requirements.

TOWER PACKING

Tellerette Tower Packing, manufactured by The Ceilcote Company, is a proven high-efficiency tower packing designed to reduce operating costs and increase collection efficiency. This filamentous toroidal helix has been used over the years in smaller sizes with effective results in wet scrubbers, cooling towers, entrainment separators, absorption and stripping columns, and air washers. It has attained acceptance in a wide range of industrial applications including the primary metals, metal finishing, pulp and paper, chemical, food, rendering, caustic chlorine and refining industries for wet scrubbing and gas liquid contact applications.

Design advantages of using Tellerette Tower Packing are as follows:

Lower pressure drops, thus lower energy requirements

Greater free volume

Less settling of packing material

Lower weight per unit volume

Free flowing; no unattached filaments to catch on edges

Tellerette Tower Packing is the first choice for many new absorption and scrubber applications and is an ideal replacement for existing ring and saddle packings - especially where greater throughput and/or efficiency is desired.

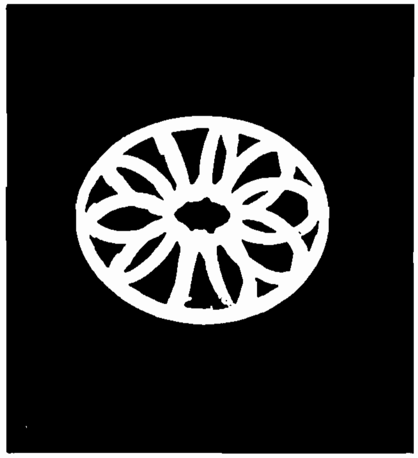
Tellerette packing is available in 1", 2", and 3" sizes and in many different materials. Five of these materials, including properties and physical characteristics are listed in table at right.

Size	Max. Dimension OD	"Loop" Height	Number Pieces/ Ft.³	Free Volume (%)	Surface Ft.²/Ft.³
1"	1.81"	0.75"	1000	87	55
2" Type-R	2.75"	1.00"	275	93	38
3" Type-R	3.75"	1.50"	102	92	30

Property	P/E	P/P	PVC	CPVC	Kynar*
Operating Temp.	210°F.	250°F.	150°F.	210°F.	300°F.
Tellerette Size	1" 2" 3"	1" 2" 3"	2"	2"	2"
Pounds Per Ft.³	7.5 3.9 5.0	7.0 3.7 4.7	5.7	6.3	7.2

*Kynar is a registered trademark of the Pennwalt Corporation.

Other thermoplastic materials also available: Tefzel, registered trademark of E.I. Dupont; Halar, registered trademark of Allied Chemical; and Ryton, registered trademark of Phillips Petroleum.



Design Tips

A. The maximum recommended service temperatures are obtained from independent published sources. Specific operating conditions may warrant adjustment.

B. Tellerette packing maintains good liquid distribution through packing depths in excess of 30'. Good initial liquid distribution is essential. Spray headers using full cone spray nozzles are preferred. Weir distributors are not recommended.

C. Design of the packing support is important. The plates or grating should have an open area of 75-80%. Intermediate supports must be of a design that will avoid maldistribution.

D. The amount of liquid holdup depends on the actual L- and G-rates through the tower. A rough rule-of-thumb for calculating liquid holdup in a 2" Tellerette packed bed is to multiply the density of the scrubbing liquid by 3% of the cubic feet of packing used in the tower or scrubber.

E. Tellerette packing can be operated at capacities up to the phase inversion point. Because of their open filamentous configuration, phase inversion in a Tellerette packed column can be reversed by simply reducing either the gas or liquid flow. The tower does not have to be shut down and restarted.

GUIDE TO CORROSION RESISTANCE

	Polyethylene	Polypropylene	PVC	CPVC	Kynar
Organic Acids	A	A	A	A	A
Inorganic Acids (mild) concentrations)	A	A	A	A	A
Nitric Acid (strong concentrations)	A	B	A	A	A
Cl_2 Gas	B	C	A	A	A
Alkalis	A	A	A	A	A
Solvents	B	B	B	B	B
Chlorinated Hydrocarbons	B	B	C	C	A

A = Excellent - Good to maximum temperature of product

B = Satisfactory - Some attack by all or certain chemicals in this group

C = Not recommended

III. TECHNICAL

1.0 INTRODUCTION

1.1 GENERAL

1.1.1 Spray Drying. For dry scrubbing to be fully adaptable in industry, it is essential that the spray absorber be economically viable, meet specified emission standards, be fully reliable and easy to operate under automatic control. As a result of large scale pilot plant testing, Joy Manufacturing Company in conjuction with their licensor, Niro Atomizer, has developed a spray absorber design for acid gas and particulate removal. The heart of the system is the Niro Atomizer rotary centrifugal atomizer with the special patented KN abrasion-resistant wheel. The atomizer is designed for extremely reliable, continuous operation with minimal maintenance. The KN wheel consists of a machined body with removable silicon carbide inserts in wear areas. With routine, scheduled maintenance the unit will operate reliably for many years. The atomizer is capable of virtually infinite reagent flow turndown without significantly altering the particle size distribution of the atomized liquid. This feature, which is unique to rotary centrifugal atomizers, assures uniform control of water evaporation rates, acid gas absorption, and end-product characteristics over a wide range of gas flow rates. The simple flue gas dispersing system gives full utilization of the spray absorber (dryer chamber). The chamber features dry waste product discharge from the base of the drying chamber so as to eliminate any chance of exhaust duct blockage following any operational process upset.

The main reasons for developing the spray dryer approach to flue gas cleaning are:

a) High degrees of HCl and SO_2 removal are obtained and high flue gas rates are treated in a single dryer unit (absorption module).

b) The process is dry and simple to operate. There are no problems involving scaling and equipment plugging.

c) The dryer (absorption module) is flexible in operation with regard to varying acid gas levels, ideal for automatic control, and features a high turn-down ratio.

d) Excellent system availability, as components comprising the system have few moving parts.

e) Low absorbent to gas ratios lead to optimum use of the absorbent and minimum amounts of waste dry product for disposal.

f) There are no wet/dry interface problems.

g) There is no risk of blockage of flue gas stream and/or pressure risks.

h) There is easy transportation and handling of the dry waste product.

1.1 GENERAL (Continued)

1.1.2 Dry Absorption System. Individual components were developed and selected to handle the operational conditions unique to flue gas cleaning, they are designed to handle large gas flows, achieving stringent emission standards, and securing total plant reliability.

The spray absorber features the atomization of a suitable fluid absorbant with the resulting spray mixing with the hot flue gas stream. Spray/gas mixing enables optimum absorption of acid gas components as the spray droplets are drying. Acid-free flue gas passes to a dry collector for removal of the gas-borne particulate fines. The dry reaction products are recovered from the drying chamber and the particulate collector for disposal.

The ability to handle high gas volumes in a single spray absorber chamber simplifies the acid gas removal process. Furthermore, the spray absorber operation with its ease of outlet temperature control and gas turn-down flexibility enables optimum removal of acid gases and associated particulates (ash) in a low pressure drop system, conducive to low energy consumption per unit of flue gas treated.

1.1.3 Atomization of Absorbent. Atomization of absorbent slurry is achieved using a rotary atomizer with an abrasion resistant atomizer wheel to produce a fine spray having the required surface area for meeting the absorption load.

An important feature of the rotary atomizer is its capability of virtually infinite reagent flow turn-down without significantly altering the particle size distribution of the atomized liquid. This feature, which is unique to rotary atomizers, assures uniform control of water evaporation rates, acid gas absorption, and end product characteristics over a wide range of gas flow rates.

1.1.4 Spray/Flue Gas Contact. The gas disperser design for acid gas or high temperature inlet is in accordance with experience from high temperature utility spray dryers operating under similar temperature/air flow conditions.

The single atomizer concept has the ability to use a central atomizer/gas disperser location. This permits optimum chamber utilization for absorption through ease of control of the gas flow pattern within the chamber.

The gas disperser is a proven design for handling high air rates and turn-down ratios. The gas disperser makes possible close control of the spray trajectory from the rotary atomizer. This spray control enables full utilization of the available chamber volume and it also facilitates turn-down.

1.1.5 Reliability. The high performance of the spray dryer lies in the design features of the absorption drying chamber. The design is characterized by a single atomizer in a simple gas disperser system. Joy/Niro advocate the single atomizer concept. Experience drawn from the performance of our very large atomizers clearly shows there is no need to consider atomizer duplication merely to cover an eventual breakdown situation.

1.1 GENERAL (Continued)

1.1.6 Dry Product Recovery. Dry product formed in the chamber as a result of the absorption during drying is discharged from the base of the chamber, and fines entrained in the clean flue gas are recovered in the associated particulate collector.

The two-point product discharge, i.e., primary discharge from chamber, secondary discharge from the particulate collector is designed to eliminate any chance of blockage of the exhaust gas duct between the absorber chamber and dry collector.

Any such blockage could cause serious problems in incinerator or boiler operation. With the two-point discharge approach, separation of product from the cleaned flue gas takes place within the lower part of the chamber. Any upset in operating conditions that might cause formation of semi-wet product will cause the resulting lumps to be merely discharged from the chamber base. Under no circumstances will such semi-wet product (lumps) enter the exhaust duct to create a potential blockage hazard. On the contrary, with a single-point discharge system, non-blockage conditions in the exhaust duct cannot be guaranteed following a process operating upset, since all product and clean gas pass to the dry collector. Any semi-wet product must therefore pass into the exhaust duct and if resulting lump size and nature prevents its pneumatic conveying to the collector, a deposit will form causing the initiation of a potential blockage condition. Furthermore, the initiation of a deposit condition is not immediately detectable.

1.1.7 Particulate Collector (PULSEFLO® Fabric Filter). Following each spray dryer absorber will be one (1) PULSEFLO® fabric filter dust collector, of the compressed air pulse type cleaning concept, equipped with all the necessary controls, valves, manifolds and compressed air headers to carry out the off-line cleaning and operating functions. The PULSEFLO® fabric filter is a compact piece of equipment, especially valuable when plant space is at a premium. The selected filter is designed for continuous operation, off-line cleaning and is of modular construction and of a design philosophy that provides for low energy consumption and long bag life. Bag assemblies and cages are suspended from a tubesheet contained in a rectangular airtight housing. This unit features the top bag removal design which simplifies bag installation. The bags are removed from the unit through the walk-in plenum provided. Sufficient clearance is available to lift them vertically clear of the tubesheet and hence, out the access door. The advantages of this design are several:

- Low pressure pulsing which has demonstrated high bag cleaning capabilities and lower pressure drops on filter bags up to twenty feet (20') long.

- Removal of bags from the top allows workers to remain out of the dust in the filtering compartment.

- Simple bag snap ring allows rapid maintenance, when required.

1.1 GENERAL (Continued)

The PULSEFLO® fabric filter contains fiberglass bags with a maximum service temperature of 500°F. The use of large bags results in fewer bags being required. Using less bags results in fewer parts, such as cages, solenoid valves, venturis, etc., reducing maintenance and rebagging time. The walk-in plenum on top of the fabric filter also provides access to interior parts and the cleaning system. The collected product is removed through pyramidal hoppers.

1.2 EXPECTED/DESIGN OPERATION CONDITIONS

1.2.1 Testing. Extensive pilot investigations, (300 acfm - Columbia Maryland) established the feasibility of this spray drying process for flue gas cleaning (FGC) using lime as the reagent. This work was followed by an extensive product testing program (20,000 acfm - Fergus Fall, Minnesota), which verified process reliability and established the variables affecting process performance. On going research and development now includes regular operation of a 5,000 acfm flue gas cleaning pilot plant in Copenhagen, Denmark, which can simulate virtually any combination of specific conditions. Additional research and development is being conducted at the first full-size power plant demonstration module (115 MW; 640,000 acfm) in operation at the Northern States Power's Riverside Station located in Minneapolis, Minnesota.

Niro Atomizer has gained extensive design and scale-up experience from more than 5,000 industrial spray drying installations, where laboratory tests were routinely used as the basis for plant specifications and performance guarantees.

Joy and Niro Atomizer have also performed a series of pilot plant tests for plants which have specific performance conditions and design requirements. These pilot programs, conducted at test facilities in Copenhagen, Denmark, demonstrated the operation and toxic gas removal capabilities of the Niro dry scrubber system. In fact, removal efficiencies of 99% for HCl were obtained at low equivalence ratios (ER).

The attractiveness of the spray absorption technique lies in the ease at which an absorption system with a rotary atomizer can handle large gas volumes. Atomizers, gas dispersers, and chamber designs are already being used to treat high flue gas rates.

Acidic flue gases, containing HF, HCl, SO_2 and SO_3, are cleaned during a single pass through a spray dryer. Niro Atomizer has been closely associated with this development utilizing to full advantage know-how available from the design and operation of large spray drying plants delivered during the last five decades to the utility, incineration, biochemical, chemical and mining industries.

Niro Atomizer is unique in having supplied the world's largest spray dryers. This expertise, supported by extensive pilot plant studies investigating acid gas absorption in spray dryers, has enabled Niro Atomizer to offer a spray dryer design concept that addresses foreseeable future needs in flue gas cleaning.

III. TECHNICAL (CONTINUED)

3.0 **SYSTEM DESCRIPTION** The process gas cleaning system includes one (1) spray dryer absorber for gas cooling and acid gas removal, one (1) fabric filter for particulate and dry absorbent collection and other auxiliary equipment. The induced draft fan, stack and associated ductwork are to be supplied by the Purchaser.

3.1 **METHOD OF OPERATION** Lime milk is pumped (by Purchaser) from the reagent storage tank to the head tank where it is diluted to the final feed concentration. The head tank is agitated to assure thorough mixing. A flow control valve which adjusts automatically to maintain constant SO_2 levels determines the quantity of slurry delivered to the head tank. The head tank is relatively small to allow rapid response to changing acid gas levels, and provides a constant head of feed material to the atomizer. An overflow line delivers the excess slurry back to the vibrating screen and into the reagent storage tank.

Dilution water is delivered to the head tank by means of a level control on/off valve.

In order to reduce material buildup in the transfer lines (at low flow rates), eliminate the need for variable speed pumps, and maintain a constant flow during all operating conditions, process pumps are to be designed for a constant liquid flow rate with a return loop.

Feed flows by gravity from the head tank through a self-cleaning in-line screen to the feed control valve and then to the atomizer.

Total liquid feed rate to the atomizer is continuously controlled to maintain a constant spray dryer outlet gas temperature.

3.1 **METHOD OF OPERATION** (Continued)

Untreated flue gas is introduced into the spray dryer absorber via the central refractory lined gas disperser which provides uniform and intimate gas/liquid mixing over a range of inlet gas flow rates. The gas contacts a fine spray of lime slurry, and acids in the gas are absorbed into the alkaline droplets as water is simultaneously evaporated. Acid gas removal efficiencies can be varied by changing the atomizer feed concentration. Careful control of gas distribution, slurry flow rate and droplet size assures that the droplets are evaporated to dryness prior to touching the internal walls of the spray dryer absorber. A portion of the dry product falls to the bottom of the absorption chamber.

The treated exhaust gas, at a controlled outlet temperature flows to the particulate collector, where the remaining suspended solids are removed.

PULSEFLO® Fabric Filter

The bags are mounted on wire cage frames which prevent them from collapsing. The particulate is deposited on the outside of the bags as the gas flows through them. Fabric filter compartments are individually isolated from the gas flow for cleaning. The bags are then cleaned by pulses of compressed air cleaning one row at a time.

A short blast of compressed air is injected into each bag controlled by Joy's automatic programmable controller. Each controller, an integrated circuit solid-state device, can control up to twenty circuits. Each circuit actuates a diaphragm dust filter valve which release the compressed air into air headers above the bags and, via an orifice into the bags.

The compressed air pulse creates a shock wave that travels down the bag's length. This wave rebounds to double the cleaning action. The particulate adhering to the outside of the bag is broken loose by the shock wave and falls into the hopper beneath the compartment.

3.2 **CONTROL PHILOSOPHY** To fulfill the required removal efficiencies with minimum reagent consumption, it is important to operate the absorber with the lowest practical gas outlet temperature. Extensive pilot testing has demonstrated that absorption efficiency improves as the absorber outlet temperature decreases. This fact must be weighed against the aggressive nature of the chloride ions. The outlet temperature from the spray dryer absorber was selected for reliable removal of the acid gases, to have a free-flowing powder, and to protect all downstream equipment from potential acid attack due to leaks.

Additionally, since the collected ash will contain many chloride salts, the hygroscopic nature of the ash requires a higher outlet temperature to assure a free-flowing product.

Slurry flow rate to each atomizer will vary primarily as a function of the evaporative heat load, i.e., gas flow and gas temperature drop across each absorber. The alkalinity (lime content) in this slurry is adjusted automatically to fulfill the absorption requirement by changing lime slurry concentration in the head tank.

The control system is designed to produce the proper quantity of feed slurry to cool the gas to the preset outlet temperature and is thereby designed to control the acid gas outlet emission.

Each outlet temperature controller will keep a constant gas outlet temperature from the absorption chamber by an error signal to the feed flow-control valve in the feed pipe to each atomizer. The actual amount of feed slurry delivered to the atomizer will be a function of flue gas temperature.

4.3 LIME SLURRY PREPARATION AREA

4.3.1 Feed/Head Tanks. A constant-level atomizer feed head tank is provided to feed lime slurry by gravity to the atomizer. The tank is constructed of carbon steel and includes inlet, outlet, overflow and drain connections. A security screen is furnished to prevent oversize particles from entering the atomizer feed line.

4.4 SPRAY DRYER ABSORBER AREA

4.4.1 Spray Dryer Absorber Chamber. The spray dryer absorber chamber provides for the mixing of the atomized absorbent and the hot flue gases. The chamber consists of a sloped, structural topdeck section with checkered plate flooring, cylindrical shell and a conical bottom section and external stiffening ribs spaced as required to provide support for the chamber skin. The entire chamber will be supported to ground level by a heavy supporting ring, transferring the load to the steel structure. Chamber plate sections will be shop-rolled, match-marked and prepared for field welding. The chamber shell will be field welded.

The absorber chamber will be designed for a gas pressures of +25" and -25" w.g.

The absorber chamber will be constructed of carbon steel (ASTM A-36) material, 1/4" nominal plate thickness.

4.4.2 Gas Dispersers. A central gas (refractory lined) disperser is provided to introduce the flue gases into the spray absorption chamber. The incoming flue gases contact the atomized reagent below.

The purpose of the gas disperser is to distribute the incoming flue gases symmetrically around the atomizer unit at a velocity and direction appropriate to insure optimum absorption of the acids contained in the flue gases. The gas disperser has a venturi inlet which delivers the strengthened flue gases to the atomizer.

4.4 **SPRAY DRYER ABSORBER** (Continued)

4.4.3 Electric Hoists and Trolleys. One (1) electric hoist and trolley system is provided in the spray dryer absorber weather enclosure for the removal and movement of the atomizers.

The hoist controls shall consist of the necessary electric equipment, including heavy-duty reversing contractors, low voltage transformers and push-button pendant or wall-mounted stations.

4.4.4 Rotary Atomizers. A Niro Atomizer Type F-800 rotary atomizer is furnished for the spray dryer absorber. The atomizer provides for the atomization and conversion of the absorbing slurry to a uniform, finely divided spray of droplets.

The atomizer is a precision-made machine of the very highest quality, designed for high-speed operation and it is driven by a vertical, flange-mounted, direct coupled motor.

The atomizer is provided with a forced lubrication system, including coupled oil pump and alarm switches for oil flow failure.

The atomizer is equipped with a vibration monitor to detect spindle ball bearing failure and/or buildups in the liquid distributor or atomizer wheel. Furthermore, the atomizer is equipped with an air cooling system for protection against overheating and to cool the lube oil.

The lower base is comprised of a supporting plate, bearing bracket incorporating the main oil sump, bracket for feed pipes, including lower oil sump, skirt, skirt tip and spindle. The spindle is a special stainless steel rotating in ball bearings. Spindle and gearbox are linked by a gear coupling.

The feed pipe bracket carries the guide bearing which prevents the spindle from coming in contact with any stationary components when passing through the first critical speed. This guide bearing is furnished with self-lubricating carbon impregnated with antimony.

The skirt tip is interchangeable to suit any given atomizer wheel diameter.

The lubrication system is monitored by automatic controls operated via a control box.

The feed pipes take the absorbent slurry down to a screw-shaped slurry distributor in which the slurry is evenly distributed and smoothly accelerated before the entry to the atomizer wheel.

4.4 **SPRAY DRYER ABSORBER AREA** (Continued)

4.4.4 Rotary Atomizers (Continued)

A flooding indicator is mounted in the supporting plate. Should flooding from the leaking feed pipe or coupling occur, an alarm signal is generated.

Vibrations in the atomizer are defined as cyclical motion of the spindle in relation to surrounding components and can be measured as variations in the gap between the spindle and the end of the probe mounted in a holder in the feed pipe bracket. When the level of vibration exceeds a preset value, an alarm is activated. If the degree of vibration increases above the next present value, the atomizer is shut down automatically.

4.4.5 Atomizer Wheels. The titanium atomizer wheel is dynamically balanced to resist large centrifugal forces and the high temperature.

The wheel is a patented design, featuring wear-resistant, exchangeable bushings of silicon carbide, arranged so that a protective layer of slurry builds up in the inner wheel chamber. The bushings can be repositioned to equalize areas of wear. A pagoda-shaped, wear-resistant baseplate protects the lower wheel body.

During operation, a protective layer of slurry will settle on the inside wall of the wheel in a thickness determined by the length of protrusion. Thus, the wear will take place on the settled layer of slurry itself and not on the wheel.

When wear-tracks on the inserts appear to leave only a few mm of wear material, the inserts are turned 90 to 100 degrees. The number of possible turns, three or four, usually is dependent on the width and shape of the actual wear-track. When all tracks are worn out, the inserts are replaced.

5.5 EQUIPMENT DESCRIPTION

5.5.1 Base Modules. The complete baghouse will consist of standard PULSEFLO® modules, arranged in a double file configuration, with each of the modules containing 208 nominal 6" diameter by 20' long filter bags. Each module will be furnished with clean air walk-in plenum, housing section, and one (1) pyramidal hopper. The proposed modules will be fabricated of 3/16" mild steel plate with 3/16" mild steel tubesheet, welded construction, all stiffened for ±20, inches water column pressure. Each module tube sheet contains holes for the bags and shall provide for individual top bag/cage removal. The clean air walk-in plenum allows for maintenance out of the ambient environment. Access to the clean air plenum is via a 18" x 48" quick-opening access door.

Hopper gas inlet is located in the side of each module below the bottom of the bags. Outlets are located in the clean air walk-in plenum. The bagspacing provides for the interstitial ("can") velocity to be well within the design requirements. These design features greatly reduce bag wear and extend bag life.

The use of the walk-in plenum in lieu of the flat "hatch cover" design is preferred since it greatly reduces the linear feet of sealing surface. The walk-in plenum uses only one (1) 18" x 48" quick-opening access door per module with double davit hinges to allow compensation for gasket shrinkage. In contrast, a flat hatch cover design must utilize multiple covers with many sealing surfaces. The roof of the walk-in plenum will be self-draining.

5.5.2 Hoppers. One (1) pyramidal hopper fabricated of 3/16" mild steel plate with minimum 55° valley angle will be provided for each module.

Each hopper will have 300 cubic feet of storage capacity as measured directly below the inlet, and will include the following:

a) One (1) 24" diameter bolted access door.
b) Outlet flange.
c) Two (2) poke tubes (4" diameter) with cap.
d) One (1) 4" pounding lug/strike plate.
e) Hopper heating modules with thermostatic controls.
f) Level detectors.
g) Vibrators (controls by others).

5.5.3 Inlet and Outlet Manifolds. One inlet (1) and one (1) outlet manifold fabricated of 3/16" mild steel plate stiffened for ±30 "wg will be provided. Manifolds will include transition pieces and appropriate expansion joints. Manifolds will be all welded gas tight construction. Access to the inlet manifold will be through a 24" square bolted access door. Manifolds will be tapered to maintain uniform gas velocity and sized to minimize premature settling of dust. Inlet manifold transition pieces to each module will be located at or near the bottom of the manifold to assist in sweeping any settled dust into the module.

5.5 EQUIPMENT DESCRIPTION (Continued)

5.5.4 Dampers. Each module will be provided with manually operated butterfly dampers at the inlet and pneumatically actuated butterfly valves at the outlet (compressed air piping by others). The outlet valves will be supplied with limit switches to give indication of open/closed position.

5.5.5 Pulse-Jet Off-Line Cleaning System. A high efficiency pulse-jet cleaning system is proposed utilizing off-line cleaning as the recommended mode of operation. System components include:

a) Main compressed air header.
b) Compressed air distribution pipes.
c) Heavy duty diaphragm type pulse valves.
d) Solenoid actuators.
e) Air receiver.
f) Solid state controller.

The air distribution pipes will be of our standard design, quick disconnect for ease of removal during maintenance. Sequencing of cleaning controls and a dedicated distribution pipe per row provides that only one row of bags shall be cleaned per each compressed air pulse. Each distribution pipe will have graduated openings to assure that an equal amount of compressed air enters each bag. All compressed air piping for each baghouse will terminate at the air receiver.

The proposed cleaning system utilizes low pressure, 40 PSIG, compressed instrument air to dislodge the accumulated filter cake from the bags. Our extensive research and testing has proven that for optimum cleaning, reduced pressure loss and extended baglife, the low pressure approach is superior, and compressed air requirements are reduced.

Description of controls and cleaning cycles is contained under PULSEFLO® System Controls.

5.5.6 Bags, Cages and Accessories. The proposed filter media will be 16 oz/sq.yd. woven fiberglass with a Gortex finish. The Gortex membrane provides lowest emissions and extends bag life and provides for proper cake release.

Bags will be supplied with sewn-in snap rings that permit easy and dust tight installation. Bag cages will be of two (2) sections for ease of installation and constructed of #11 GA galvanized low carbon steel wire (20 vertical wires equally spaced with spacer rings on 6" centers). Special Quality Assurance techniques will assure that there are no rough spots on cages to cause bag abrasion or failure.

5.5.7 Painting. All exterior ferrous metal surfaces, excluding stainless steel and galvanized areas, of baghouse and other fabricated steel items will be cleaned and shop-primed.

5.6 **WALK-IN PLENUM** Walk-in plenums with a minimum 9'-6" overhead clearance from the tubesheet to module roof is supplied.

5.7 **FABRIC FILTER BYPASS SYSTEM** Provisions must be made by Purchaser for a fabric filter bypass system designed to maintain the fabric filter temperature below 500°F. Emergency stock is recommended.

5.8 **SAFETY AND WARNING FEATURES** The fabric filter is protected from high or low flue gas temperature on systems equipped with a bypass by actuation of the flue gas temperature switch upon which the programmable controller initiates a filter bypass sequence whereby the bypass damper is operated followed by the closure of the module outlet dampers. Abnormal high differential pressure across the filter will also initiate the bypass sequence described above.

The programmable controller also monitors damper closing and opening time. If any damper fails to achieve a commanded position in a prescribed time, the programmable controller issues a DAMPER STALL alarm to warn the operator of possible actuator failure.

III. TECHNICAL (CONTINUED)

6.0 AUXILIARY SYSTEMS

6.1 SYSTEM EQUIPMENT

6.1.1 Flue Work/Manifolds

Joy will supply the following 3/16" thick mild steel (ASTM A-36) ductwork:

a) Spray dryer absorber outlet to particulate collector inlet.

b) Particulate collector outlet to induced draft fan inlet.

The ducts are designed for effective gas distribution, minimum dynamic pressure losses and minimal particulate fallout.

The ducts will be of welded, shop-fabricated carbon steel construction, shipped in sizes most practicable for transportation and field erection and furnished with suitable sway-frame bracing, external stiffening, turning vanes, and access doors.

Structural design will allow for ash build-up of one (1) foot on horizontal duct surfaces.

The duct connections will require field bolting and seal welding.

6.1.2 Expansion Joints. Expansion joints are furnished as per the general arrangement drawing to facilitate duct and equipment relative movement. The joints furnished will be fabric belt-type joints with an integral three-inch (3") flange and will be fabricated to a minimum thickness of one-fourth inch (1/4"). Where practical, joints will be shipped completely assembled and ready for field installation. Joints will be furnished preset for installation at 70°F.

Expansion joints at interface with purchaser's ductwork are by purchaser.

6.1.3 Structural Steel/Support Steel. JOY will design and furnish all required structural and support steel for the equipment supplied by JOY within the battery limits required for the following:

a) Spray dryer absorber.
b) Particulate collector.
c) Ductwork.

ASTM A-36 support steel (and slide plates) will be provided with an 8'-0" clearance between the particulate collector hopper discharge flange and the bottom of the supports. The structure will be designed to accept the anticipated dust loads.

Support structures carrying loads subject to thermal expansion (movement) will be provided with a system of "Lubrite", or equal, slide plates at all required slip points.

6.1 SYSTEM EQUIPMENT (Continued)

6.1.4 Access Facilities. JOY will design and furnish access facilities as depicted on the proposal drawings. The access facilities with galvanized grating and carbon steel (ASTM A-36) handrails and toe plates will consist of the following:

a) Stairtowers.
b) Encaged ladders (used only as secondary means of egress, or infrequent access requirements).
c) Walkways.

6.1.5 Service and Maintenance Hoists. Joy will furnish service and maintenance hoists as shown on the proposal drawing and listed below.

	Capacity	Motor Rating	Quantity
SDA penthouse atomizer hoist	3 ton	3 HP	1

6.2 **ENCLOSURES** Enclosures will be provided as generally shown on the proposal drawing and as listed below:

a) Spray dryer absorber penthouse (uninsulated roofing and siding).

Joy proposes to design and furnish heating equipment (space heaters), ventilating equipment (fans, fan starters and louvers) and lighting as shown below:

	Heating	Ventilation	Lighting
a) Spray dryer absorber penthouse	X	X	

6.3 PIPING All piping, support systems, automatic and manual valves and expansion joints required for the atomizer feed pipeline are furnished.

Instrument air, and water piping will be supplied between all equipment connections and the purchaser's point of supply located near the slaking area.

The lime slurry piping will consist of schedule 40, carbon steel piping, with full-port diaphragm pinch valves for system isolation and flow control. Horizontal piping shall be sloped 1/4" per foot. Adequate flow velocities will be maintained to prevent material fallout in the lines. Slurry piping is designed to facilitate piping and equipment flushing, rodout and maintenance. Long radius bends and takeoffs from the tops of lines will be used to minimize pluggage.

All piping and control valves will be self-draining. Piping shall be routed as directly as possible, eliminating all unnecessary bends.

All piping systems will have high-point vents and low-point drains. Suction strainers with pressure taps shall be furnished for all pumps requiring their use. Equipment maintenance may be performed without dismantling pipe.

6.4 WASTE PRODUCT HANDLING

6.4.1 Knife Gates. Manually operated knife gates are provided for maintenance of the following equipment:

a) Spray dryer absorbers.

6.4.2 Delumpers. To ensure the continuous removal of material from the spray dryer absorber bottom, including any upset condition, a delumper is provided. The delumper will be mounted between the absorber bottom knife gate and rotary valve. The delumper will be fabricated of carbon steel or cast iron, with sealed ball bearing mounted shafts, high tempered replaceable shear boar, feed control gate and easy clean out door.

6.4.3 Tipping Valves. Tipping valves are provided. A tipping type valve will be mounted beneath the spray dryer absorbers and particulate collectors in order to provide a means for continuous material withdrawal and air seal maintenance.

7.0 INSTRUMENTATION AND CONTROLS

7.1 SPRAY DRYER ABSORBER AREA Joy will engineer and supply field instrumentation and control panels required for the equipment proposed herein. The control hardware to be supplied as part of this bid is as follows:

a) Gas stream monitoring includes outlet absorber temperatures.

b) Absorber lime slurry flow rate controlled by outlet temperature.

c) Atomizer comes complete with monitoring instrumentation package.

7.2 FABRIC FILTER (PULSEFLO®)

7.2.1 Instrumentation. Field located instrumentation consists of:

a) Pressure differential indicating switch to initialize fabric filter cleaning sequence.

b) Termocouples for monitoring the flue gas inlet and outlet temperature.

c) Limit switches on pneumatically operated valves.

7.2.2 Controls. The PULSEFLO® control is accomplished by a solid state programmable controller (PC). The programmable controller controls the actuation of the outlet valves and the pulsation solenoids. It also interfaces with the damper limit switches, differential pressure and temperature switches and panel indication lights and controls.

The programmable controller is housed in a control enclosure containing all necessary components and appurtanences for a totally integrated system.

7.2.3 Control Functions. The control logic is designed to minimize filter bag wear by cleaning on demand, yet maintaining the desired Delta P set point across the fabric filter. The following are some of the functions performed by the programmable controller:

a) Monitors the differential pressure across the fabric filter.

b) When the differential pressure reaches an adjustable set-point, it initiates the cleaning sequence in each module.

c) When the off-line cleaning mode has been selected, the programmable controller closes the module outlet damper and, after an adjustable delay, commands the module pulse timer to issue a series of pulses to open the diaphram valves, in sequence, for each row of bags in the module.

d) An adjustable dust settle time follows the module cleaning cycle at the end of which the outlet damper is opened.

e) After another adjustable period, the cleaning continues with the closure of the outlet damper of the next module.

f) Cleaning can also be started by an adjustable timer before the differential pressure across the filter is reached, or manually by push button actuation.

7.2 **FABRIC FILTER (PULSEFLO®)** (Continued)

7.2.4 Module Off-Line/On-Line Cleaning. The PULSEFLO® control system features off-line and on-line capabilities. The normal cleaning mode is off-line whereby bag pulsation is effected after closing the outlet valve of the module to be cleaned. On-line cleaning can be selected by actuation of the on-line command. In this mode, bag pulsation is effected with the module outlet valve open and the module still in filtering mode.

7.2.5 Module Skip Cleaning and Isolation. Any module can be taken off line and isolated for maintenance during filtering operation. Upon actuation of the "SKIP CLEANING" command the selected module outlet valve closes and the cleaning operation skips the isolated module on every cleaning cycle.

7.2.6 Cleaning Manual Start. When desired, fabric filter cleaning can be initiated by actuation of the "MANUAL START" command. In this mode each module is cleaned in sequence once with the cycle ending at the last module on line.

7.2.7 Alarms. The PULSEFLO® control system provides as a minimum the following alarm outputs for remote annunciation:

a) High inlet gas temperature.
b) Low inlet gas temperature.
c) High differential pressure.
d) Outlet valve stall.
e) Cleaning sequence stall.

7.2.8 Outlet Valve Stall. The programmable controller monitors the outlet valve limit switches. If, after a command a valve does not achieve the corresponding position in a preset time an alarm is issued to alert the operator.

7.2.9 Cleaning Sequence Stall. The progammable controller also monitors the bag pulsation cycle. If pulsation of the last row of bags for each module is not detected in a preset time, an alarm is issued.

FLORIDA FIRST PROCESSING, L.P.

APPENDIX D-4-4

CARBON MONOXIDE AND OXYGEN ANALYZER

ENDA - 1000

OPERATION

MANUAL

June 1988

HORIBA INSTRUMENTS INCORPORATED

HORIBA INSTRUMENTS INC.
1021 DURYEA AVENUE
IRVINE INDUSTRIAL COMPLEX
IRVINE, CALIFORNIA 92714
TELEPHONE 714/250-4811

Operation Manual

ENDA-1000 Series

Stack Emission Analyzer System

HORIBA, Ltd.
Kyoto, Japan

Preface

This manual is designed to be applicable to all HORIBA ENDA-1000 Series Stack Emission Analyzer System models. The reader is therefore advised to bear in mind the particular model number and specifications ordered when referring to this manual.

For information on installation of the ENDA-1000 Series, refer to the separate manual entitled "Instructions for Installation." Similarly, for information on the Option Unit, supplement this manual with the separate Operation Manual provided for the ECU-350 Option Unit.

Table of Contents

1. General Description

1-1 System Construction

A standard package of the ENDA-1000 Series incorporates a Sample Probe/Primary Filter Assembly and an Analyzer System. The Sample Probe/Primary Filter Assembly is installed directly in the smoke stack while the Analyzer System is designed for installation on a flat, level surface or on the floor. These two installations are connected by a sample line that may be provided by the user or can be ordered separately as an option from HORIBA.

Sample Probe/Primary Filter Assembly

Most of the dust in the smoke stack gas collected at the Sample Probe is removed by the Primary Filter, to which the Sample Probe is directly connected. In order to prevent condensation of moisture, the Primary Filter is heated to a temperature of about 110°C by an electric heater integrated in the assembly.

After passing through the Primary Filter, the sample gas passes along a sample line separately provided by the user to the Analyzer System. This line should also be heated in order to prevent condensation of moisture. In some cases, it may be necessary to fit a drain trap near the end of the sample line. A sampling pump is incorporated in the Analyzer System.

Analyzer System

The Analyzer System contains a Sample Handling System and an Analyzer Unit packaged in a 19-inch rack mountable case. The entire System is enclosed in a steel cabinet for outdoor installation. Depending upon the specifications, the Analyzer System may be supplemented by an Option Unit packaged in a similar 19-inch rack mountable case.

When the sample gas enters the Analyzer System, the temperature must be lower than 40°C and such that it is not saturated with moisture. The gas passes through a Sample Handling System consisting of a mist catcher, a particulate filter, flow selector valves, a pump, a dehumidifier, a pressure relief water trap, etc., before it is led into the Analyzer Unit.

Analyzer Unit

The Analyzer Unit of the ENDA-1000 Series is capable of simultaneously measuring the concentration of up to three different components in the sample gas and providing separate output of the measurement results. In other words, it is possible to mount two infrared analyzer modules and one magnetopneumatic analyzer module. Available combinations of components for measurement with a single analyzer unit are shown in Table 1 on page 1 - 4.

After measurement; the sample gas must be expelled to a safe place with no fluctuation in backpressure.

Versions

ENDA-1000 Series Analyzer Systems can be broadly divided into those versions that use purified air* as zero gas (span gas in the case of an O_2 analyzer) and those versions where both zero gas and span gas is supplied from gas cylinders. Both types are available in manual calibration control versions and automatic calibration control versions. The components that make up the Analyzer System vary in each case.

* The air purifier is built into the Analyzer System.

Table 1 Model Number and Applications

MODEL NBR	APPLICATIONS
ENDA-1120	NOx (NDIR-CFM)
ENDA-1130	SO2 (NDIR-CFM)
ENDA-1140	CO2 (NDIR-CFM)
ENDA-1150	CO (NDIR-CFM)
ENDA-1160	O2 (MPA)
ENDA-1220	NOx (NDIR-CFM) + O2 (MPA)
ENDA-1230	SO2 (NDIR-CFM) + O2 (MPA)
ENDA-1240	CO2 (NDIR-CFM) + O2 (MPA)
ENDA-1250	CO (NDIR-CFM) + O2 (MPA)
ENDA-1300	NOx (NDIR-CFM) + SO2 (NDIR-CFM)
ENDA-1310	NOx (NDIR-CFM) + CO2 (NDIR-CFM)
ENDA-1320	NOx (NDIR-CFM) + CO (NDIR-CFM)
ENDA-1340	SO2 (NDIR-CFM) + CO2 (NDIR-CFM)
ENDA-1350	SO2 (NDIR-CFM) + CO (NDIR-CFM)
ENDA-1370	CO2 (NDIR-CFM) + CO (NDIR-CFM)
ENDA-1400	NOx (NDIR-CFM) + SO2 (NDIR-CFM) + O2 (MPA)
ENDA-1410	NOx (NDIR-CFM) + CO2 (NDIR-CFM) + O2 (MPA)
ENDA-1420	NOx (NDIR-CFM) + CO (NDIR-CFM) + O2 (MPA)
ENDA-1440	SO2 (NDIR-CFM) + CO2 (NDIR-CFM) + O2 (MPA)
ENDA-1450	SO2 (NDIR-CFM) + CO (NDIR-CFM) + O2 (MPA)
ENDA-1470	CO2 (NDIR-CFM) + CO (NDIR-CFM) + O2 (MPA)

(NDIR-CFM):

Non-dispersive infrared analyzer with cross-flow-modulation technique

(MPA):

Magneto-pneumatic oxygen analysis

1-2 Sample Requirements

It is a prerequisite that the sample gas to be measured by the ENDA-1000 Series fulfills the following conditions at the point where it enters the Sample Probe.

Temperature:	250°C or lower[1]
Pressure:	Atmospheric pressure ± 100 mm H_2O[2]
Dust:	0.1 g/Nm^3 or less
Composition:	SO_2 - 2,000 ppm or less
	SO_3 - 1/10 SO_2 or less
	NO - 1,000 ppm or less
	NO_2 - 1/10 NO or less
	CO - 1,000 ppm or less
	CO_2 - 5 to 15 vol%
	O_2 - 0.2 to 15 vol%
	H_2O - 4 to 20 vol%[3]
	Must contain no NH_3, HCl, HF, Cl_2 or other corrosive components, nor any components that cause an easy chemical reaction when in contact with the component(s) to be measured.

Remarks:

1) The sample gas collected at the Sample Probe is to be led to the Analyzer System via a sample line, heat-jacketed if necessary, after it passes through the Primary Filter. The sample gas entering to the sample inlet of the Analyzer System Console must be at near to the ambient temperatute.

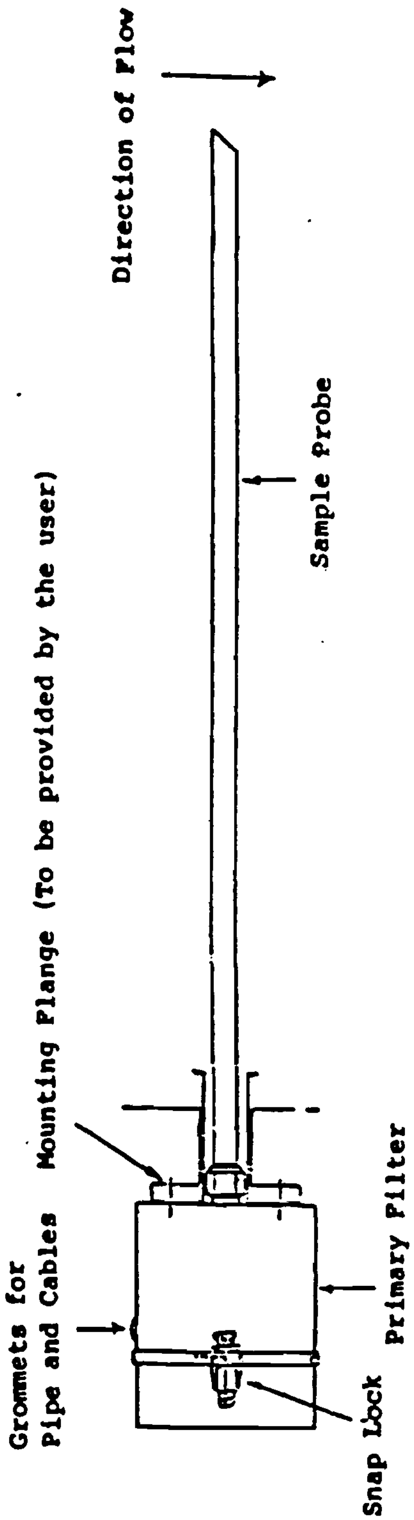
2) The pressure cited assumes the use of the optional sample line available from HORIBA, which is a Teflon tube with inner diameter of 6 mm and maximum length of 50 meters.

3) Moisture content at the sample inlet of the Analyzer System must be below saturation point (no dewing).

Note: Refer to the separate manual entitled "Instructions for Installation" should the conditions of the sample gas fall outside the ranges given above.

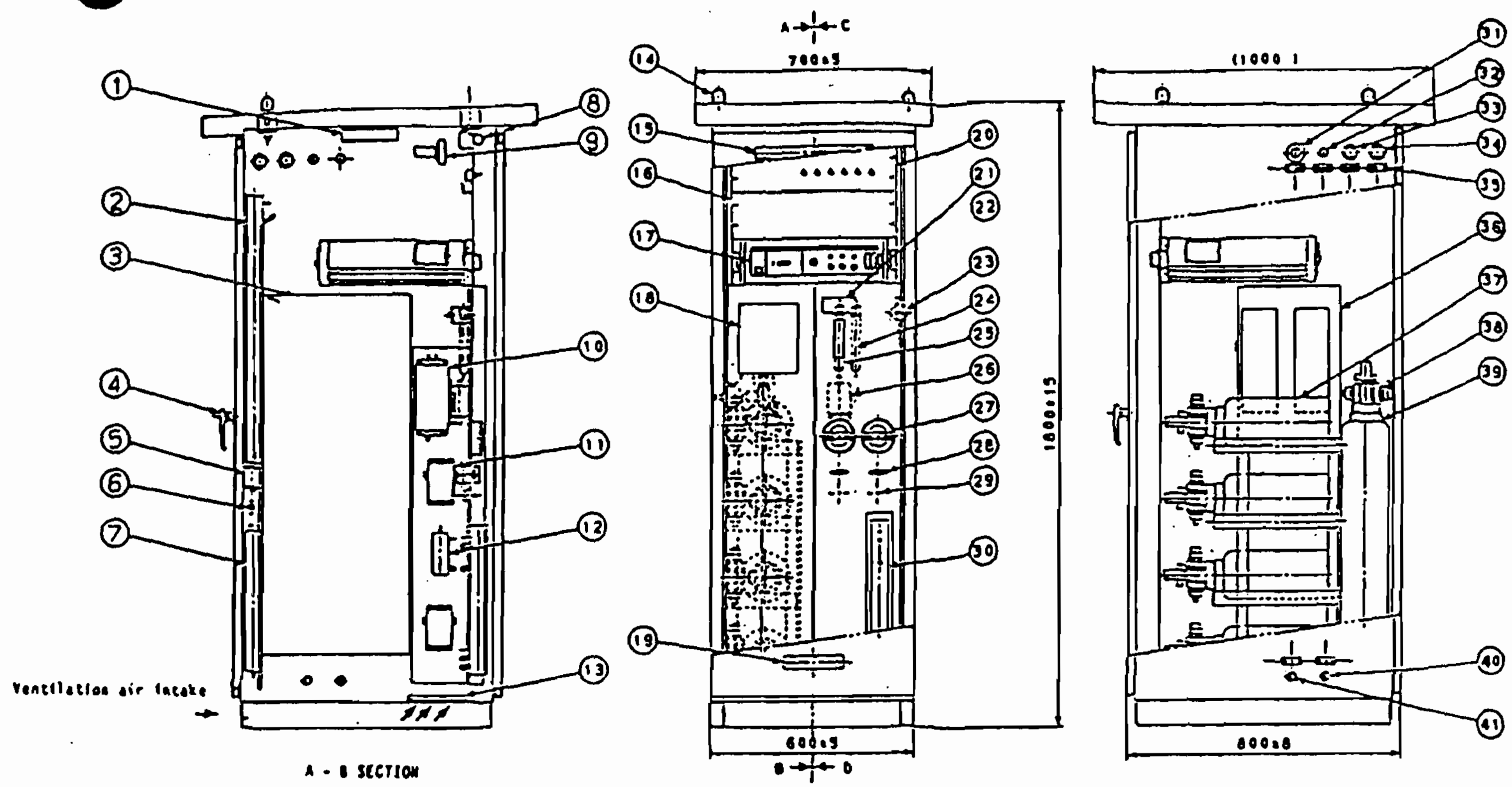
2. Parts Location

2-1 Sample Probe/Primary Filter Assembly



2-2 Analyzer System

Following illustrations cover two (2) typical, basic versions of the Analyzer System console. One is the manual control version the gas flow of which is selected manually by the selector valves on the front panel, and the other is the automatic control version with the Option Unit installed that controls the solenoid valves to switch the gas flow and the electronic zero/span calibrations. The parts to be mounted and the actual location of them may differ depending upon your Analyzer System specifications.

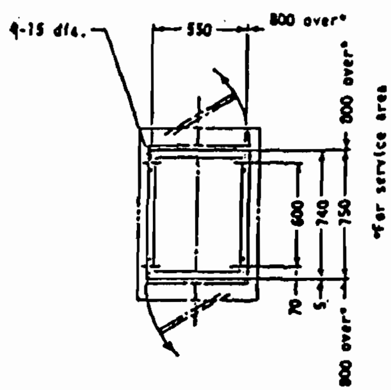


A - B SECTION

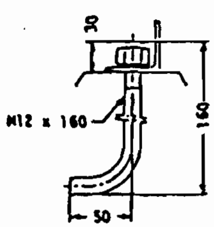
FRONT VIEW
(front door partially erased)

C - D SECTION

REF	Description
1	Ventilation Fan
2	Drain Separator, PVC
3	Terminal Board
4	Door Handle
5	Air Filter
6	Check Valve
7	Buffer Tank, PVC
8	Fluorescent Lamp
9	Thermostat, ventilaton control
10	Dehumidifier, thermoelectric
11	Pump, duplex
12	Bubbler, PVC
13	Filter Pad, ventilation air
14	Eye Bolt
15	Name Plate (A), product name
16	Option Space, blanck panel
17	Analyzer Unit
18	Recorder Space
19	Company Logo
20	Switch Panel
21	Name Plate (B), Range ID
22	
23	Air Filter
24	Scrubber
25	Mist Catcher
26	Converter, NO2-to-NO
27	Particulate Filter
28	Selector Valve, 4-way, PVC
29	Needle Valve, PVC
30	Pressure Relief Water Trap
31	Sample Inlet, 8mm/6mm
32	Conduit Connector, PF 1/2 F
33	Conduit Connector, PF 1 F
34	Conduit Connector, PF 1 F
35	Guide Label
36	Relay Board
37	Gas Cylinder, 3.4-liter
38	Cylinder Regulator, WR-11-NS
39	Gas Cylinder, 10-liter
40	Sample Outlet, PT 1/2 F
41	Drain Outlet, PT 1/2 F



Recomm. Floor Plan



Anchor Bolt Installation

Remarks:

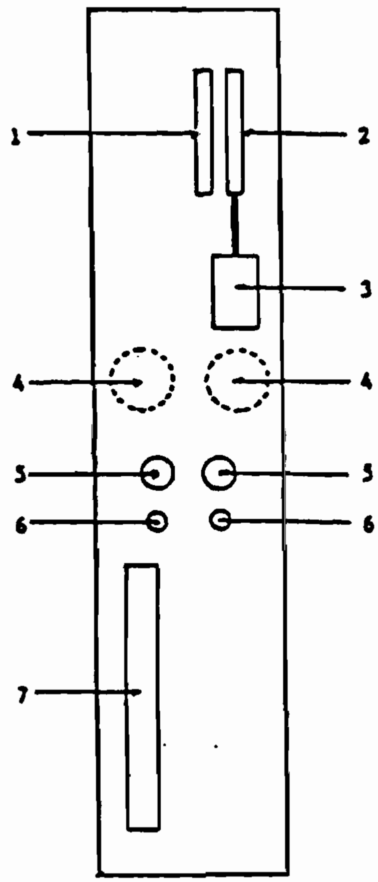
1. The parts 5 through 7 are supplied only for O_2 application.
2. The parts 21 and 22 are supplied only if applicable or specified.
3. The part 26 is supplied only for NOx application.
4. The part 36 is supplied as option.
5. The parts 37 through 39 are supplied as options.
6. A stepdown transformer is mounted inside the cabinet, if specified.

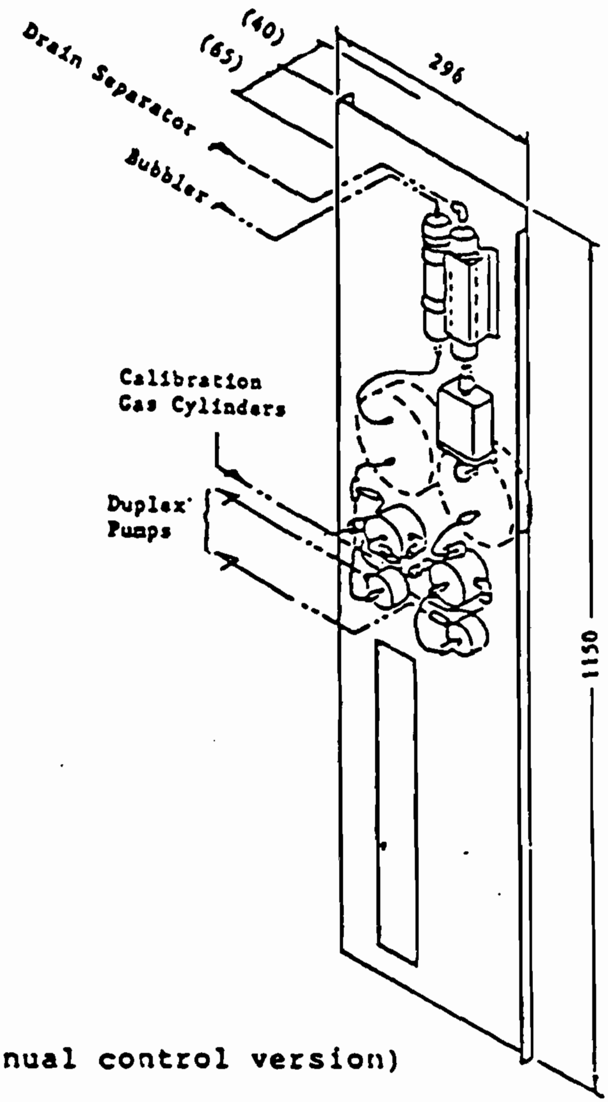
Note: The drawing shows an application of Manual Control Version.

DIMENSIONAL OUTLINES
ANALYZER SYSTEM/manual control
ENDA-1000 SERIES

2-3 Sample Handling System

Front panel, lower right

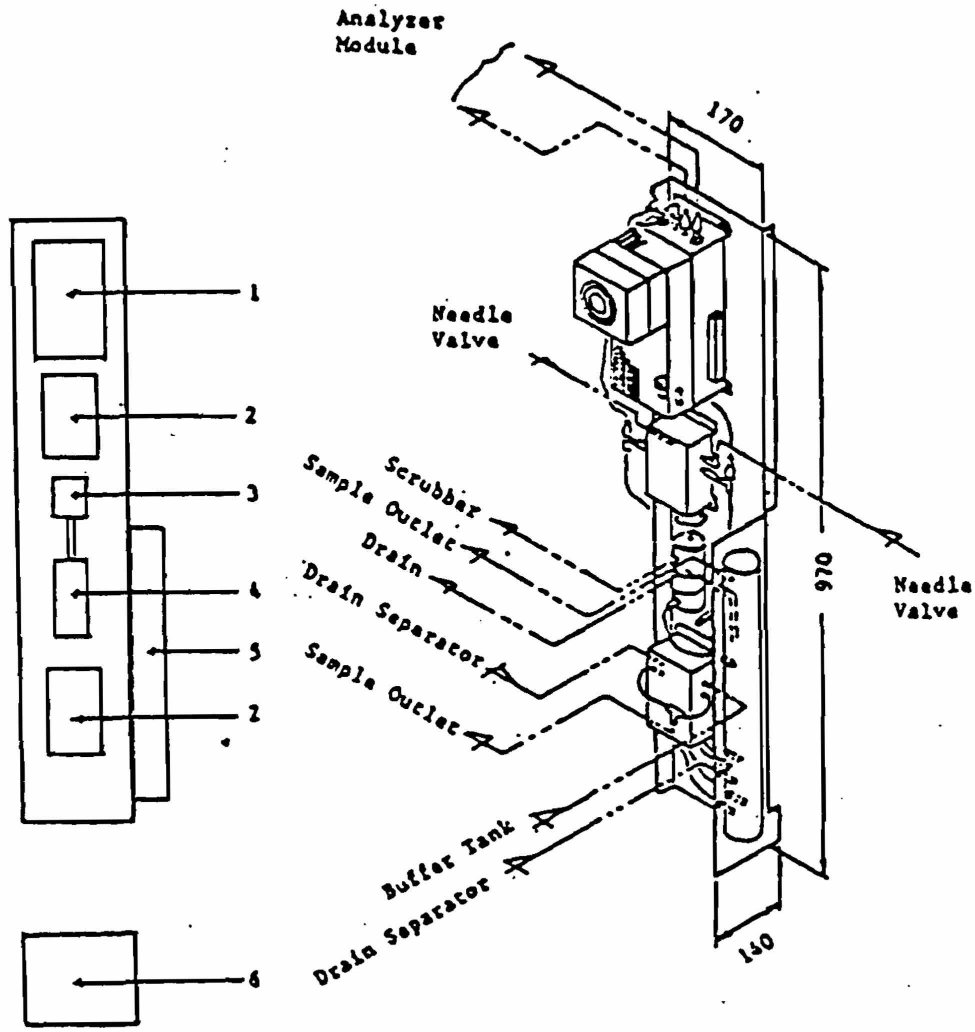




(Manual control version)

1. Scrubber SCR-1
2. Mist Catcher MC-1
3. Converter COM-1 (for NOx application only)
4. Particulate Filters F-2 & F-3
5. 4-way Selector Valves SC-1 & SC-2
6. Needle Valves V-1 & V-2
7. Monitor Window

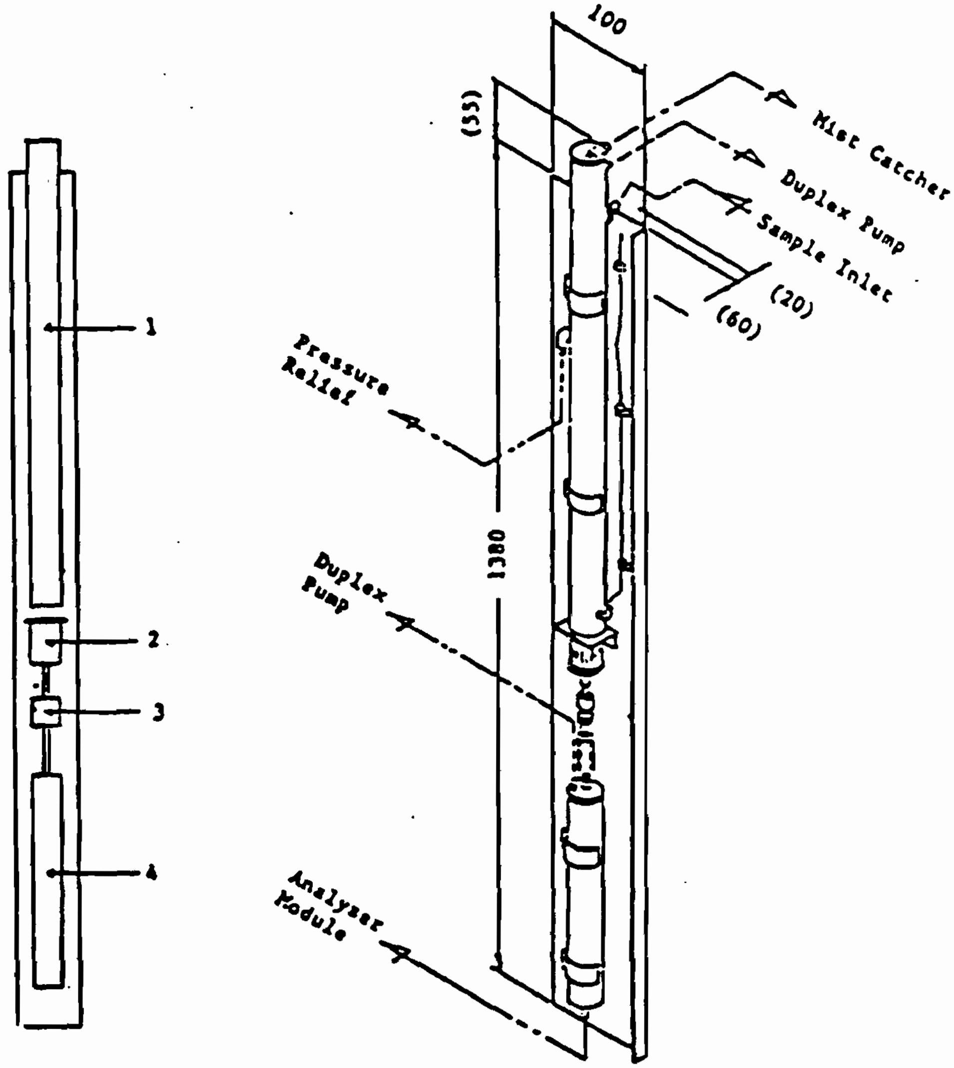
Front panel, lower right
(interior)



1. Thermoelectric Dehumidifier C-1
2. Duplex Pumps P-1 & P-2
3. Air Filter F-5
4. Bubbler B-1
5. Pressure Relief TR-1
6. Power Unit for C-1* (to be mounted separately)

* Power Unit for C-1 is not shown in the illustration

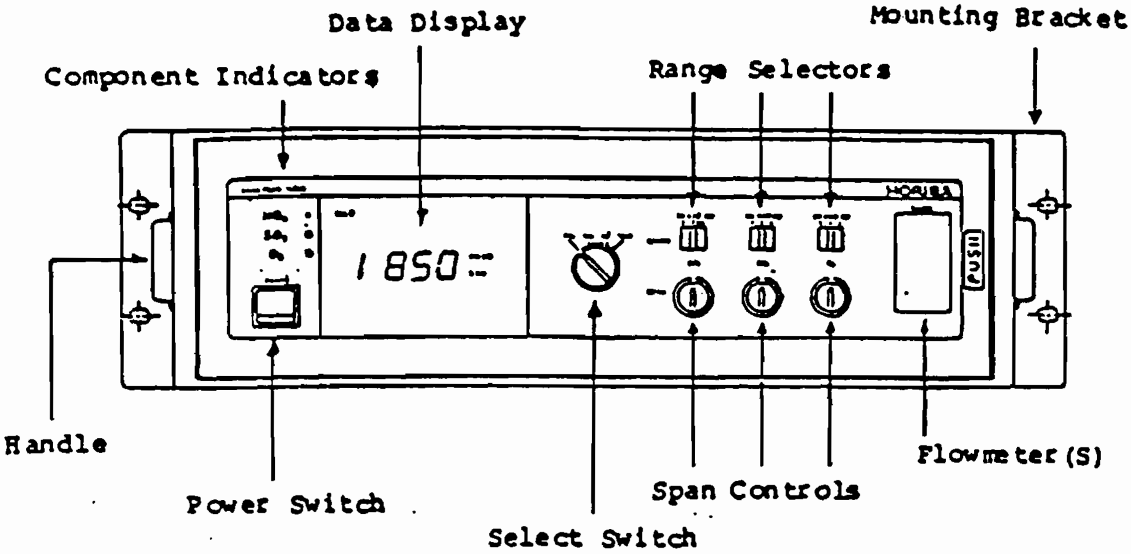
Bottom left-hand corner
when rear panel is open



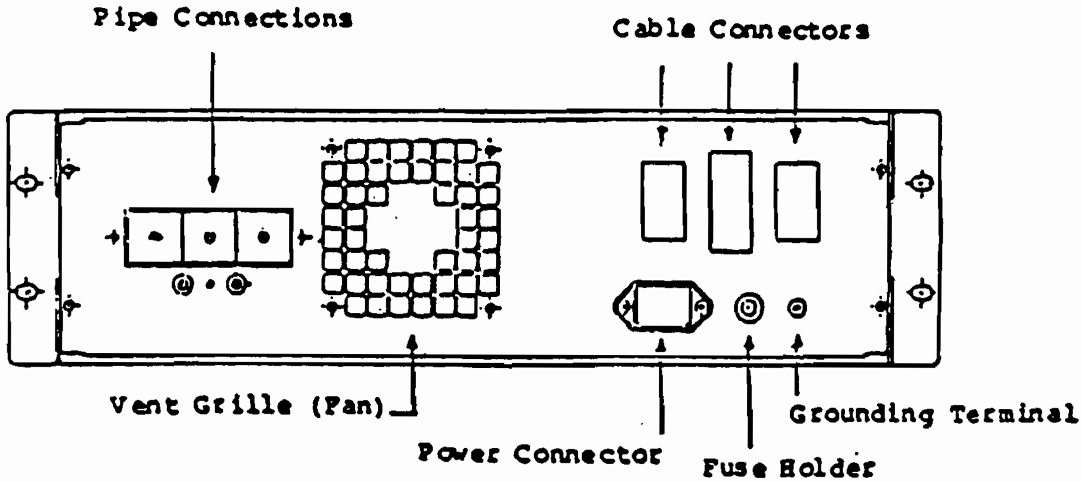
1. Drain Separator DS-1
2. Air Filter F-4 (for O_2 applications only)
3. Check Valve CV-1 (for O_2 applications only)
4. Buffer Tank BT-1 (for O_2 applications only)

2-4 Analyzer Unit

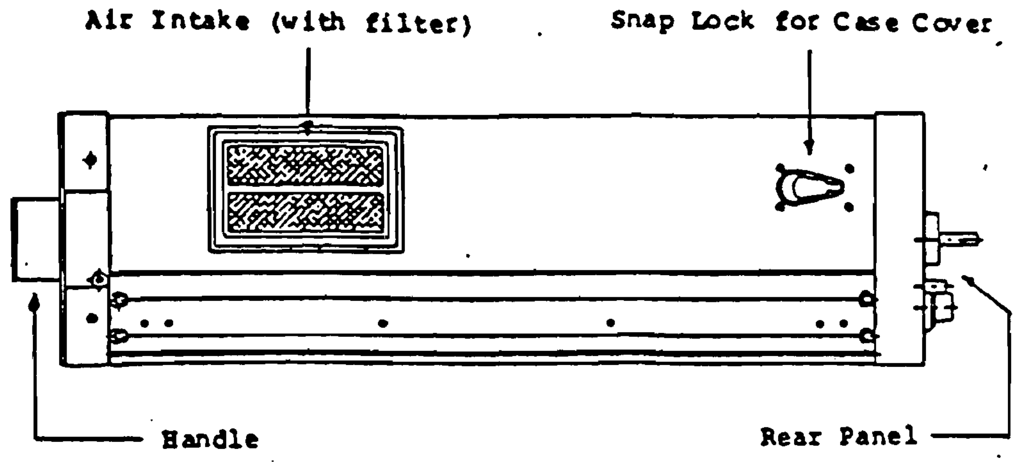
a) Front Panel



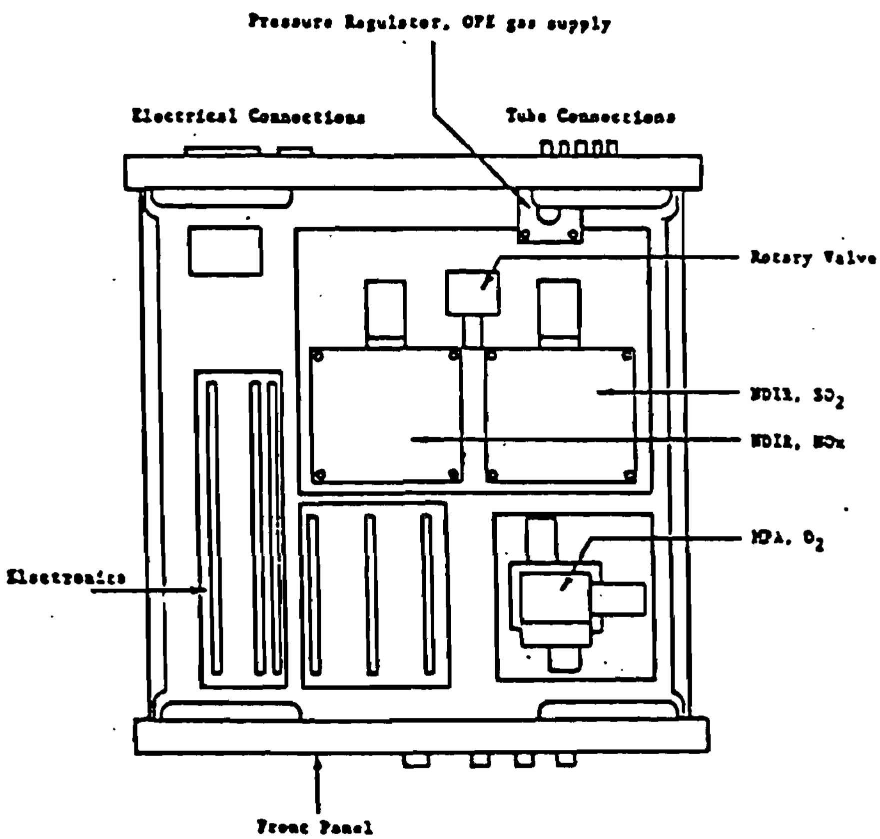
b) Rear Panel



c) Side View



d) Interior Layout (case cover removed)



3. Installation and Connections

3-1 Installation

Ordinarily, the Sample Probe/Primary Filter Assembly and Analyzer System are both shipped in a fully assembled state. For installation guidance, refer to the separate manual entitled "Instructions for Installation."

CAUTION

1. Check that the voltage and frequency of the power line to be connected match the specifications.
2. The power to heat up the Primary Filter must be supplied from the Analyzer System Console.

Remove the stoppers that may have been inserted for transportation purposes.

Dismounting and Remounting

If for some reason it becomes necessary to remove the Analyzer Unit and/or Option Unit, if included, from the Analyzer System Console, use the following procedure.

a) First check that all POWER switches on the Analyzer System and Analyzer Unit are in the OFF position. Then disconnect all cable and pipe connections on the rear panel of the Analyzer Unit.

   CAUTION: Take care not to remove the ID labels on the cable connectors and tubes.

Power Connections

AC Line Voltage: The AC voltage hot line prescribed in the specifications is to be connected to the H terminal and the neutral line to the N terminal of terminal T_0.

Ground Line: The ground line (earthing line) should be connected to terminal T_2 on the lower part inside the Analyzer System Console.

Power Distribution: The AC line voltage is transformed to 100 V AC by the step-down transformer inside the console, after which the power is distributed via terminal board T_1 to the internal equipment in the system and the primary filter assembly. AC voltage (100 VAC) for the Analyzer Unit and Option Unit, if installed, is supplied separately from the two outlets located on the right of terminal board T_5.

Cable Connection Between Option Unit and Analyzer Unit

If your ENDA-1000 Series includes the ECU-350 Option Unit, the Analyzer Unit and Option Unit are connected by a single cable with connectors attached. The two ends of the cable are connected to the connectors labeled "OPTION" on the rear panels of the two units, and it is this cable that allows the two to function. An Analyzer System combined with an Option Unit can output measurement value signals only if this cable is connected.

Service Outlet

The power outlet located above the fuse holder is for service purposes and may be used for connecting equipment or a device at 100 V AC, up to 1 A.

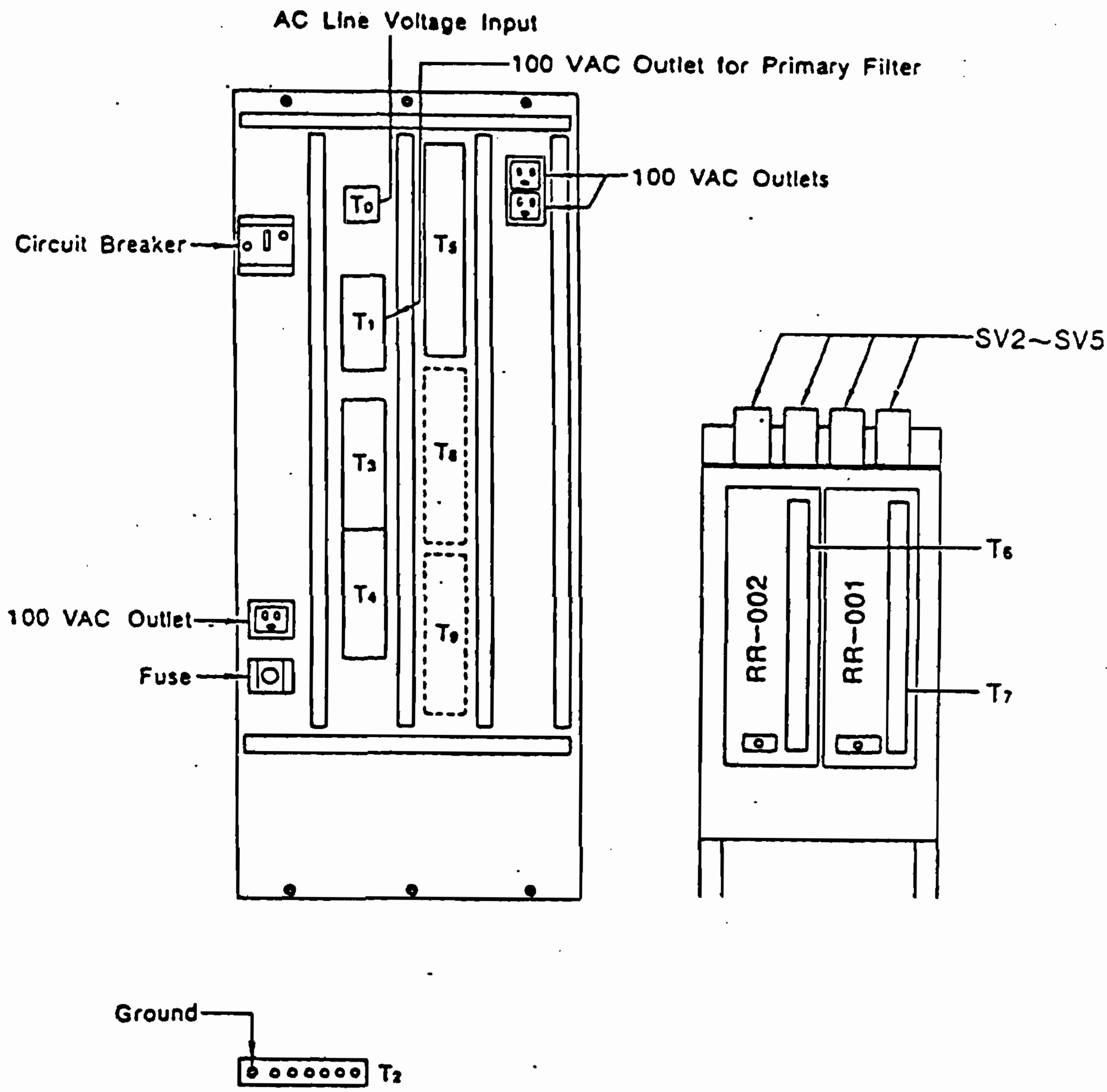
WARNING

No matter what the circumstances, always switch the circuit breaker OFF when removing cables or disconnecting wires connected to a terminal. In any procedure that requires touching terminal T_0, further ensure that the main switch for the external power line is also OFF. Failure to do so may lead to electric shock and/or damage to equipment.

Location of Terminal Boards

The position of the terminal boards and the cable connections on the rear panel of each unit are shown on the following pages. Refer to the appended drawings for details of external connections to terminal boards.

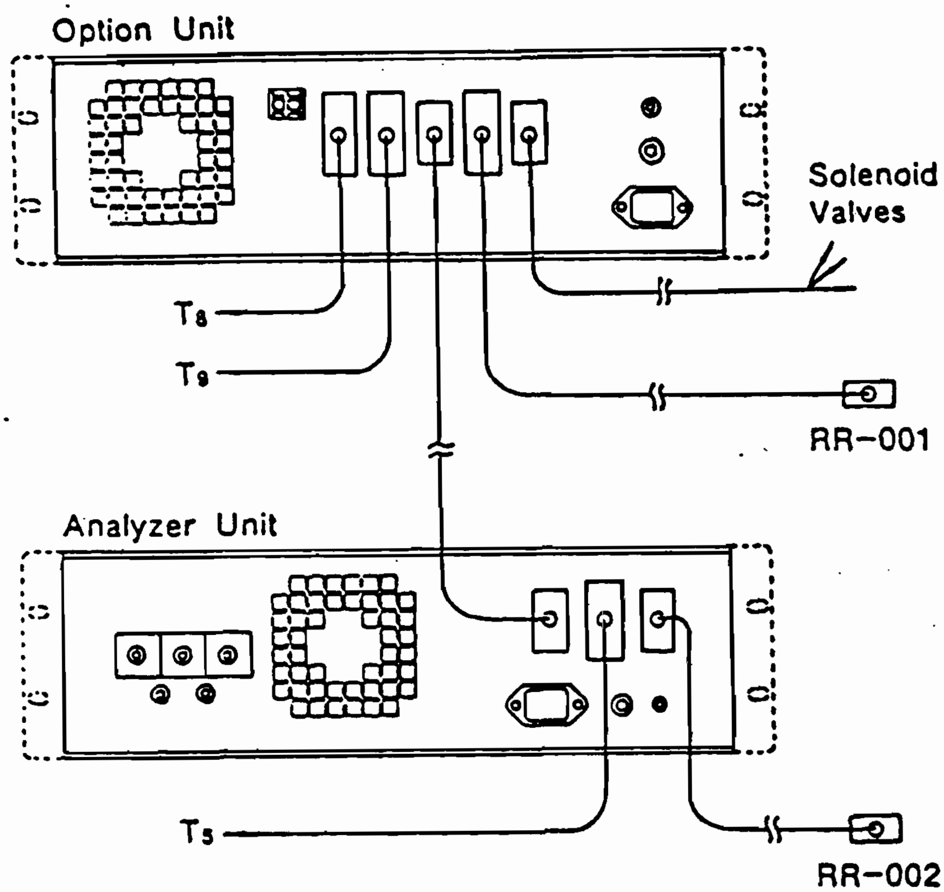
Location of Terminal Boards and Power Connections



Notes;

1 Power to the primary filter assembly is supplied at T1 terminal board.
2. Signal interface to external equipment is provided at T5 terminal board.
3. T8 and T9 terminal boards are for additional signal outputs provided by an optional ISD module.
4. T6 and T7 terminal boards are integrated in RR-002 and RR-001 circuit boards respectively.

Cable Connections Between Analyzer Unit and Option Unit



Notes;

1. Cable to T5 is for signal interface.
2. Cable to RR-002 is for status identification to external equipment.
3. Cables to T8 and/or T9 are provided if an ISO module is specified.
4. Cable to RR-001 is for status identification and remote control by external equipment.
5. Each end of cable to solenoid valve is equipped with a 2-pin connector.

3-3 Gas Supply

A. Sample Gas

Connect the end of the sample line to the tube connector labeled SAMPLE IN located in the upper right corner of the right-hand panel of the Analyzer System cabinet.

CAUTION: To prevent dewing inside the Analyzer System should the sample gas contain excess moisture, install a drain trap upstream of SAMPLE IN.

Make sure that there is no leakage at any point in the sample introduction line.

Note: Leakage in the sample line may lead to measurement error.

B. Calibration Gas

Prepare the qualified gases listed below and connect to the appropriate gas inlet nozzles of the 4-way valve (or the solenoid valve in the case of the automatic calibration control version), inside the Analyzer System Console.

Note: Space is provided in the Analyzer System Console for mounting the gas cylinders.

B-1 Zero gas

99.99% N_2 bottled in a 3.4-liter cylinder
Delivery pressure: 0.5 kg/sq.cmG (0.049 MPa) ± 10%
Consumption: 0.7 to 0.8 ℓ/min, during zero calibration only

Note: No zero gas cylinder is necessary for an air zero/span version except the ENDA-1160.

B-2 Span gas(es)

N_2 base span gas(es) of specific concentration(s) in 3.4-liter cylinder(s)
Delivery pressure: 0.5 kg/sq.cmG (0.049 MPa) ± 10%
Consumption: 0.7 to 0.8 ℓ/min, during span calibration only

CAUTION: The concentration of the span gas connected to the Analyzer System must be between 60% and 95% of the full scale range of the Analyzer Unit to be calibrated.

When an O_2 analyzer has been specified along with infrared analyzer(s) in the case of an air zero/span version, this span gas is used for zero calibration of the O_2 analyzer.

Note: No O_2 span gas cylinder is necessary for an air zero/span version in which purified air is used as O_2 span gas.

C. Operation Gas

Prepare a qualified gas listed below when an O_2 analyzer has been specified and connect it to the appropriate gas inlet located on the rear panel of the Analyzer Unit.

99.99% N_2 or CO_2 in a 10-liter cylinder
Delivery pressure: 0.5 kg/sq.cmG (0.049 MPa) ± 10%
Consumption: 5 to 6 ml/min, continuous

Note: Space is provided in the Analyzer System Console for mounting the gas cylinder.

The above-mentioned gas cylinders may be provided by the user or can be ordered separately as options from HORIBA.

CAUTION: Each gas cylinder should be fitted with a cylinder pressure regulator with appropriate pressure gauge.

CAUTION: The gas pressure of the cylinders must be higher than 10 kg/sq.cmG (1 MPa) at all times.

D. Sample Exhaust

Connect the exhaust tube to the hose-end connector labeled SAMPLE OUT in the lower right corner of the right-hand panel of the Analyzer System cabinet. Take the end of the exhaust tube to a place with atmospheric pressure and no fluctuation in backpressure for the sample to be expelled.

CAUTION: Make sure that the exhaust tube is not kinked or bent or otherwise constricted or blocked. Constriction or blockage will not only make it impossible to obtain proper readings from the analyzer, it may also cause the water in the pressure relief water trap to bubble over.

E. Drain Discharge

Connect the pipe to the outlet labeled DRAIN in the lower right corner of the right-hand panel of the Analyzer System cabinet. Take the other end of the pipe to an open place at atmospheric pressure for drainage.

CAUTION: Make sure that the drain discharge pipe is not bent or otherwise constricted or blocked. Constriction or blockage will not only make it impossible to obtain proper readings from the analyzer, it may also cause the water in the pressure relief water trap to bubble over.

3-4 Pressure Relief Water Trap and Bubbler

In order to maintain the proper gas flow to the Analyzer Unit of the ENDA-1000 Series, the water level in the Pressure Relief Water Trap must always be kept at the overflow level. The water level in the Bubbler is maintained automatically at the same level as the Pressure Relief Water Trap.

CAUTION: If the water level in the Pressure Relief Water Trap falls below the overflow level, it may lead to irregular analyzer readings.

Prior to commencing operation, fill the Pressure Relief Water Trap and Bubbler with water using the following procedure.

Remove the rubber plug at the top of the Drain Separator located inside the rear panel of the Analyzer System Console and fill with clean tap water until water flows out from the DRAIN outlet of the Analyzer System Cabinet. This fills the Drain Separator, the Pressure Relief Water Trap and the Bubbler with a sufficient amount of water. Replace the rubber plug and confirm that it is tight.

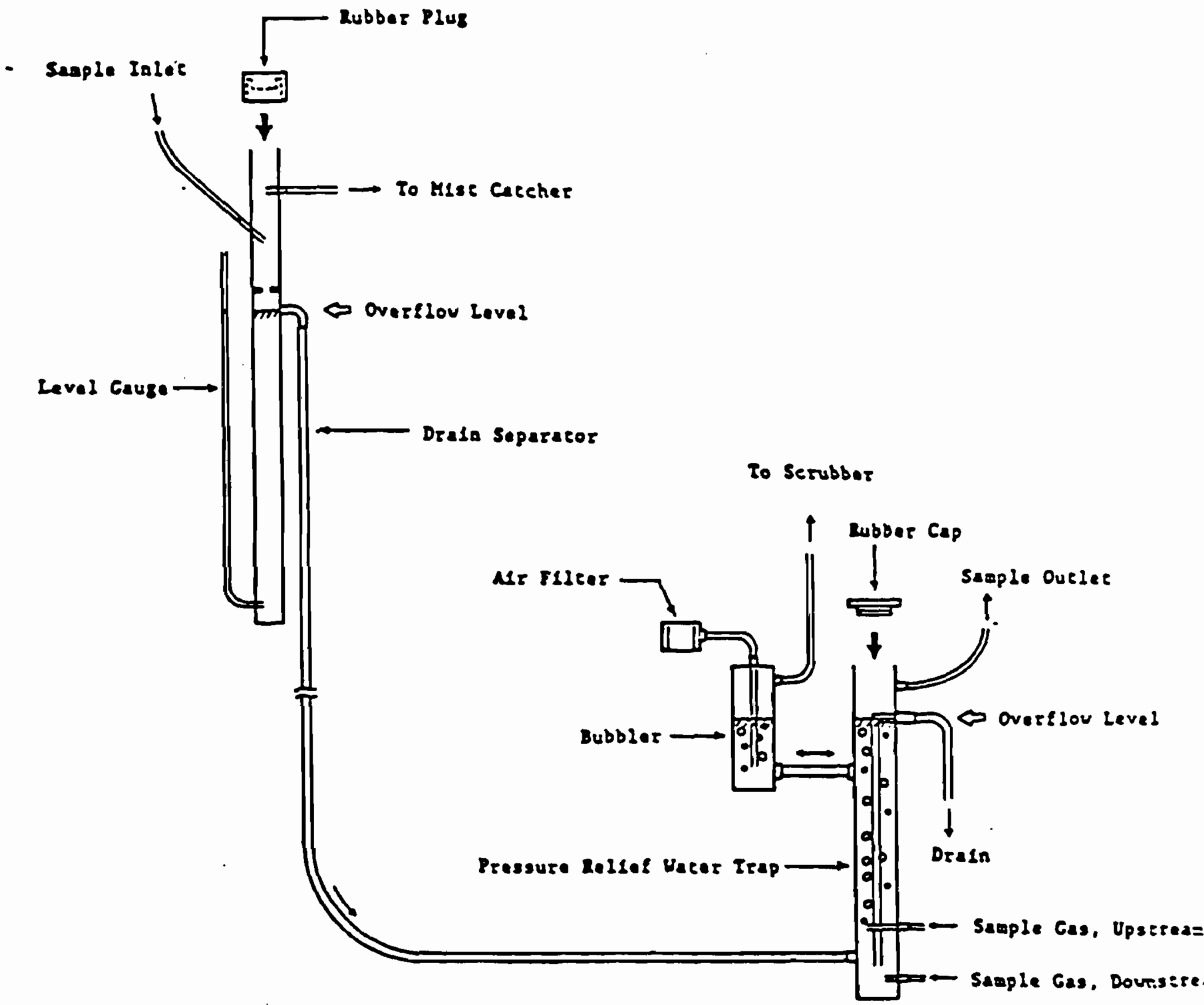
CAUTION: If the rubber plug is loose enough for ambient air to penetrate, it may lead to measurement errors.

The water level is expected to be maintained by excessive moisture in the sample falling into the Drain Separator during measurement and replenishing any loss.

CAUTION: Always visually check the water level before starting operation if sample measurement has been interrupted.

See the illustration on the following page for the water flow system.

Water Flow System



c) Prepare the Sample Handling System in the Analyzer System as follows.

c)-1 Pour clean tap water into the Drain Separator until the water comes out from the DRAIN outlet of the Analyzer System console

c)-2 Check to see the water in the Pressure Relief Water Trap is at the overflow level

c)-3 Check to see the water in the Bubbler is at the same level as that of the Pressure Relief Water Trap (except in the ENDA-1160).

CAUTION: If the water level in c)-2 is below the overflow level, top it up with clean tap water until it overflows

c)-4 All Particulate Filters should be fitted with clean Filter Elements

c)-5 All Selector Valves should be in the MEAS position (manual control versions only)

c)-6 All needle valves should be almost as far to the right as they will go (about 10% open)

c)-7 Open the main valves on all gas cylinders and adjust the cylinder pressure regulators so that the pressure gauges read the specified values

4-2 Warming Up

After checking all the items mentioned under 4-1, operation of your ENDA-1000 Series analyzer system may be started by following the procedure outlined below.

a) Switch the circuit breaker inside the Analyzer System Console to the ON position.

   Note: Open the rear door of the Analyzer System console to access the circuit breaker.

b) Turn the LAMP switch on the top panel of the Analyzer System Console to the ON position so that the fluorescent lamp lights up. Then turn the PRIMARY FILTER switch ON. Power will flow to the heater in the Sample Probe/Primary Filter Assembly.

   CAUTION: If the sample line is heat-jacketed, turn the power to the heat jacket on at the same time.

c) Turn the FAN switch on the top panel to the ON position.

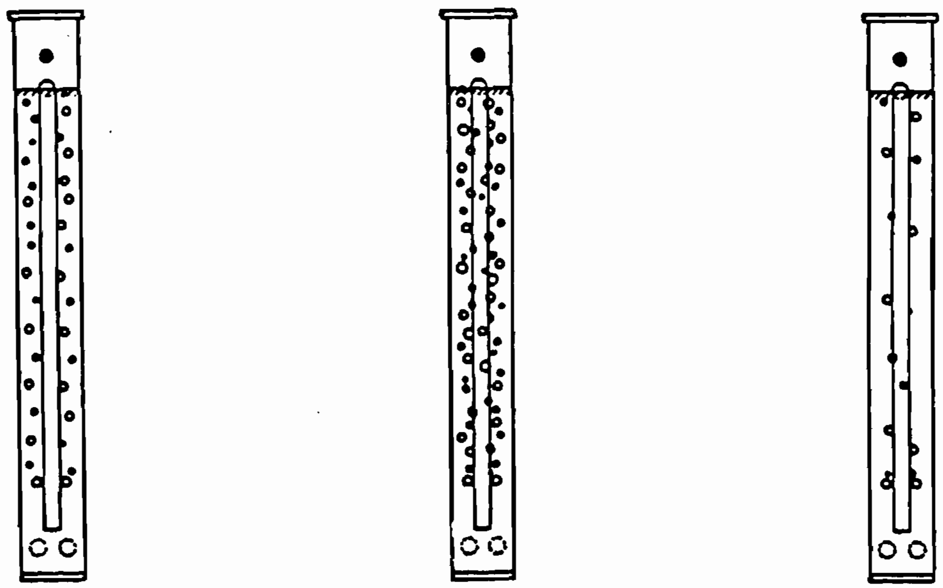
d) Wait about 10 to 15 minutes, then open the lower front panel and check that the Dehumidifier pilot lamp inside is flashing occasionally (not at frequent intervals). After confirming this, turn the Analyzer Unit POWER switch ON.

e) Wait 15 to 20 minutes for the Analyzer Unit to warm up, then turn the PUMP switch on the top panel ON. The pump will start to run and the sample gas to flow into the system.

CAUTION: It is essential to wait for the Analyzer Unit to warm up. The PUMP switch must not be turned on immediately after turning the Analyzer Unit POWER switch ON.

f) Watching the Pressure Relief Water Trap through the monitor window at the bottom of the front panel, adjust the two needle valves until the two streams of continuous air bubbles* are the same.

Note: * The illustration below shows the way the streams of air bubbles should ideally look.



GOOD	TOO FAST	TOO SLOW
	Turn needle valve clockwise	Turn needle valve counter-clockwise

The GOOD illustration shows how the air bubble streams look when the sample gas is being introduced properly to the Analyzer Unit. For safety's sake, check that flowmeter FM-1 reads 800 to 1200 mℓ/min. Also check that the FM-2 flowmeter reads 30 to 40 mℓ/min when O_2 measurement is specified.

g) Next, introduce the zero gas.

Note: If an Option Unit is installed, make sure the POWER switch on the Option Unit is in the ON position.

g)-1 In the case of a manual control version
Turn the selector valve(s) to the ZERO position.

g)-2 In the case of an automatic control version
Press the MODE switch on the AIC module in the Option Unit to light up the ZERO pilot lamp.

h) Adjust the zero gas cylinder regulator, watching through the monitor window as explained in f), so that the air bubbles in the Pressure Relief Water Trap look like the GOOD illustration.

Note: This adjustment is unnecessary in the case of an air zero/span version.

i) Next, introduce the span gas.

i)-1 In the case of a manual control version
Turn the selector valve(s) from the ZERO position to the SPAN position.

i)-2 In the case of an automatic control version
Press the MODE switch on the AIC module in the Option Unit to light up the SPAN pilot lamp.

5. Calibration

After the Analyzer has been warmed up for enough time to stabilize as explained in 4-2, it should be calibrated according to the following procedure.

The directions below refer to a manual control version for which NOx/SO_2/O_2 have been specified (equivalent to the ENDA-1400). For automatic control versions, refer to the separate ECU-350 Option Unit Operation Manual.

Note: The following explanation covers calibrating RANGE 1 for NOx and SO_2 and RANGE 2 for O_2.

Turn the RANGE SELECT switches on the Analyzer Unit to the following positions:

NOx: R1, SO_2: R1, O_2: R2

5-1 Zero Calibration for NOx and SO_2 Readings

It is not necessary to carry out the following zero calibration procedures for an automatic control version.

a) Turn the Analyzer System selector valves to the CAL-ZERO position.
   The following gases will flow to the Analyzer Unit at this time:

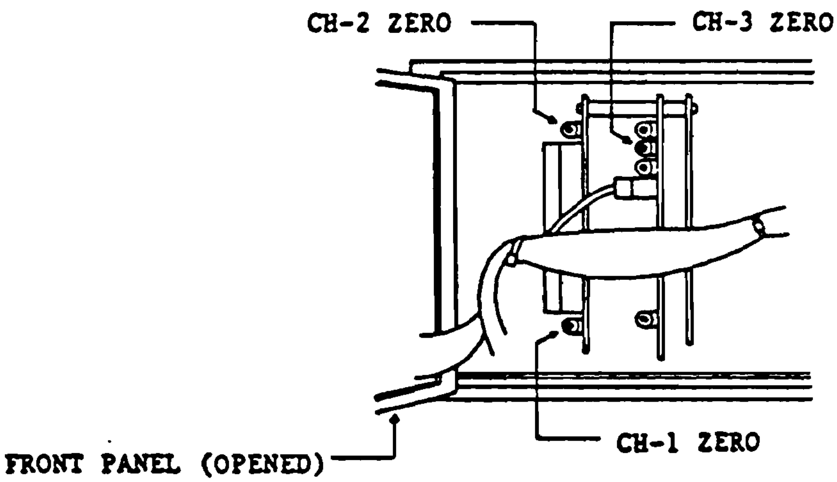
   a)-1 In the case of an air zero/span version
   Purified air: This is zero gas for the NOx and SO_2 analyzer modules, 21.0 vol% span gas for the O_2 analyzer

a)-2 In the case of a gas cylinder version

99.99% N_2 gas: This is zero gas for all analyzer modules

CAUTION: Check that the air bubbles in the Pressure Relief Water Trap are as shown in 4-2 h) and the flowmeter readings are normal. These checks should be made every time the position of the selector valves is changed.

b) Turn the SELECT switch on the Analyzer Unit to the NOx position and read the DATA DISPLAY.
After the reading stabilizes, open the front panel of the Analyzer Unit and adjust the CH1 zero potentiometer inside until the display reads zero (000).



Note: The zero readings of the analyzer modules in the ENDA-1000 Series are extremely stable and it is often unnecessary to adjust the zero potentiometers provided that sufficient time is allowed for proper warm-up.

c) Turn the SELECT switch on the Analyzer Unit to the SO_2 position and read the DATA DISPLAY.
After the reading stabilizes, open the front panel of the Analyzer Unit and adjust the CH2 zero potentiometer inside until the display reads zero (000).

The above procedure completes zero calibration for NOx and SO_2 readings.

5-2 Span Calibration for NOx and SO_2 Readings

It is not necessary to carry out the following span calibration procedures for an automatic control version.

a) Turn the Analyzer System selector valves to the CAL-SPAN-CH1 (NOx) position.
   N_2 base NOx span gas will flow to the Analyzer Unit at this time.

   CAUTION: The span gas should have a value 80% to 90% of the full-scale reading of the analyzer being calibrated.

b) Turn the SELECT switch on the Analyzer Unit to the NOx position and read the DATA DISPLAY.
   After the reading stabilizes, push in and turn the NOx SPAN control on the front panel of the Analyzer Unit until the reading matches the NOx span gas value.

   Note: The SPAN control is designed to turn while being continuously depressed; it will return to the original position if one's hand is removed. The SPAN control must not be turned once span calibration is completed. The same applies to the SPAN control in all of the following calibration steps.

c) Repeat steps a) and b) for SO_2.

This completes span calibration for NOx and SO_2 readings.

5-3 Zero/Span Calibration for the O_2 Reading

This step varies depending upon the version.

a) In the case of an air zero/span version

a)-1 Leave the selector valves as they are to allow the N_2 base span gas to flow as zero gas for the O_2 analyzer module, turn the SELECT switch on the Analyzer Unit to O_2 and read the DATA DISPLAY.
After checking that the reading has stabilized, open the front panel of the Analyzer Unit and adjust the CH3 zero potentiometer inside until the display reads zero (000).

a)-2 Turn the Analyzer System selector valves to the CAL-ZERO position. Purified air will flow to the Analyzer Unit.
Check that the DATA DISPLAY reading has stabilized and push in and turn the O_2 SPAN control on the front panel of the Analyzer Unit until the display reads 21.0 vol%.

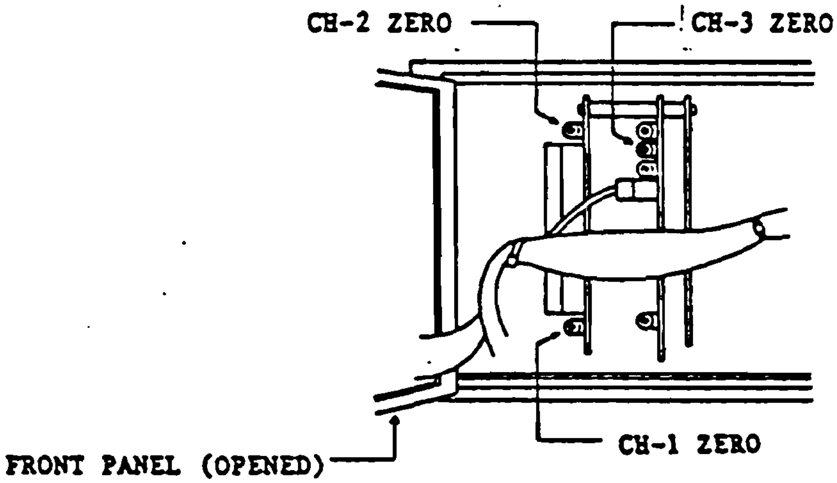
b) In the case of a gas cylinder version

b)-1 Turn the SELECT switch on the Analyzer Unit to the O_2 position and read the DATA DISPLAY.
After the reading stabilizes, open the front panel of the Analyzer Unit and adjust the CH3 zero potentiometer inside until the display reads zero (000).

b)-2 Turn the selector valves to the CAL-SPAN-CH3 (O_2) position. N_2 base O_2 span gas will flow to the Analyzer Unit.
After the reading has stabilized, push in and turn the O_2 SPAN control on the front panel of the Analyzer Unit until the reading matches the value of the O_2 span gas.

Steps 5-1 through 5-3 complete calibration. The Analyzer Unit will read the sample values once the selector valves are returned to the MEAS position.

Note: Except in the case of an automatic calibration version, close the main valves of the the zero gas and span gas cylinders when calibration is completed.



6. Sample Measurement

After calibration is completed, turn the selector valves to the MEAS position (manual control version*). Sample gas will flow to the Analyzer Unit and it will be possible to read the accurate value of the component in question from the DATA DISPLAY.

Note: * In the case of an automatic control version, press the MODE switch or START/RESET switch on the Option Unit AIC module and the MEAS lamp will light up. For details, refer to the ECU-350 Option Unit Operation Manual.

Turn the SELECT switch on the Analyzer Unit to select the component to be displayed on the DATA DISPLAY.

7. Shut Down Procedures

7-1 Precautions

The ENDA-1000 Series system is designed for continuous operation, so it is desirable to leave the power on (leave the system on STAND-BY) even when measurement is interrupted. If it is essential to turn off the power for some reason and the system is to be left off for long enough to cool down, the following precautions must be taken.

a) Sample gas should not be allowed to remain in any part of the Analyzer System.

b) The shut down procedures outlined in 7-2 should be properly followed.

c) Main gas cylinder valve(s) should be closed to prevent gas flowing.

d) It should be borne in mind that the system requires the specified time (2 to 3 hours) to warm up again once it has cooled down.

e) Care should be taken to assure that no corrosion ensues.

7-2 Power Cut Off

Follow the procedure outlined below when cutting off the power supply.

a) Purge any sample gas remaining in the sample path inside the Analyzer System with zero gas (purified air in the case of an air zero/span version).

a)-1 In the case of a manual control version
Turn the Analyzer System selector valves to the CAL-ZERO position.

a)-2 In the case of an automatic control version
Press the MODE switch on the Option Unit AIC module to light up the ZERO pilot lamp.

Note: In this mode, any sample gas remaining in the system will be replaced by purified air in the case of an air zero/span version and N_2 gas in the case of a gas cylinder version.

b) Keep the system in the condition reached after carrying out a) for at least 15 minutes.

c) Turn the Analyzer Unit POWER switch OFF.

d) Turn the Option Unit POWER switch OFF, if applicable.

Note: Refer to "5-9 Power Failure" in the Option Unit Operation Manual.

e) Turn the PUMP switch on the top panel of the Analyzer System OFF. Then turn the PRIMARY FILTER switch OFF.

f) Turn the LAMP switch on the top panel OFF and check that the MAINTENANCE switch is OFF. Then turn the circuit breaker inside the Analyzer System OFF.

g) Close the valves on all gas cylinders.

CAUTION: If the power remains cut off for some time, it is essential to flush the sample path in the Analyzer System occasionally with zero gas to prevent trouble arising from condensation of moisture that may penetrate the system.

7-3 Stand-by Status

If it is not essential to cut off the power but it is wished to interrupt sample measurement, it is best to keep the Analyzer System on stand-by. This status has the advantages of preventing soiling of the sample path within the Analyzer System and reducing warm up time when it is wished to resume sample measurement.

The following procedure is used to put the system on stand-by.

a) Purge any sample gas remaining in the sample path of the Analyzer System with zero gas (purified air in the case of an air zero/span version).

a)-1 In the case of a manual control version
Turn the Analyzer System selector valves to the CAL-ZERO position.

a)-2 In the case of an automatic control version
Press the MODE switch on the Option Unit AIC module to light up the ZERO pilot lamp.

Note: In this mode, any sample gas remaining in the system will be replaced by purified air in the case of an air zero/span version and N_2 gas in the case of a gas cylinder version.

b) Keep the system in the condition reached after carrying out a) for at least 15 minutes.

c) Leave the Analyzer Unit POWER switch ON.

d) Turn the Option Unit POWER switch OFF, if applicable.

Note: Refer to "5-9 Power Failure" in the Option Unit Operation Manual.

e) Turn the PUMP switch on the top panel OFF.

f) Close the valves on all gas cylinders.

CAUTION: In the case of an air zero/span version, it is advisable to run purified air through the system periodically.
In the case of a gas cylinder version, it is advisable to run zero gas through the system periodically.
Check through the monitor window periodically and top up the water in the Drain Separator and Pressure Relief Water Trap when it becomes necessary.

8. Maintenance Service

Regular service is required to keep the Stack Emission Analyzer System working normally at proper performance levels. The details and frequency of service required will vary depending upon the installation site and sample conditions, and the user should bear these factors in mind when determining the ideal service standards. Guidelines for determining these standards follow.

CAUTION: Failure to provide proper service after installation may lead to damage from internal causes or the external environment. This can happen even when the system is not in use. It is therefore essential to continue necessary maintenance and service routines even if measurement is discontinued for some reason or other.

8-1 Routine Maintenance Service

a) Sample Probe/Primary Filter Assembly

a)-1 At least once a month, and more often if sample conditions demand it, take off the cover, remove the Primary Filter Element and make sure that it is not clogged or soiled. If necessary, blow clean air through in the opposite direction to the sample flow to clean it or replace with a new element.

CAUTION: If the Primary Filter is badly soiled, it will be impossible to obtain the required sample flow to the Analyzer Unit.

Also remove and clean the seal packing including the O-ring. Replace with new if seriously warped or damaged.

CAUTION: If the seal packing is warped or damaged enough to allow leakage, it will lead to incorrect measurement values.

WARNING

The primary Filter is heated to approximately 110°C during operation. Keep the Primary Filter Assembly heated for the time of service. Use heat insulating, protective gloves for service. Cooling down the Primary Filter Assembly is not recommended.

Note: Apply a little silicone stopcock grease to the O-ring before replacing it in position.

a)-2. About once every three months, check inside the Sample Probe for clogging or soiling. Clean if necessary.

b) Sample Line

Under normal circumstances, check for clogging or soiling once or twice a year during periodic servicing.

c) Analyzer System

c)-1 Drain Separator

The water must always remain at the overflow level. If the level drops, remove the rubber plug at the top of the Drain Separator and top up with clean tap water until water flows out from the DRAIN outlet port at the bottom of the Analyzer System console. Replace the rubber plug.

Note: During normal operation, moisture in the sample condenses in the Drain Separator to keep it topped up. If the sample contains little moisture, however, or if measurement is suspended, evaporation will cause the water level to drop.
If no water overflows from the Drain Separator, the water level in the Pressure Relief Water Trap to which it is connected will drop and the resulting change in the sample flow to the Analyzer Unit will affect the analyzer reading.

c)-7 Pressure Relief Water Trap

Make sure that the water remains at the overflow level. See c)-1.

d) Air Filter

Check once every six months or so. Replace with new if badly soiled.

e) Calibration

The performance of the ENDA-1000 Series Analyzer Unit is extremely stable, and one can normally expect the specified precision to be maintained providing zero and span calibration is carried out once a week.

f) Analyzer System Console

Open the front door, remove the three screws holding the ventilation air filter retainer at the bottom, take out the filter net, and brush away any dust. The frequency at which this cleaning is required depends on how much dust is in the ambient air.

g) Calibration Gas(es)

Check the primary pressure of the calibration gas cylinder(s) occasionally and replace the cylinder(s) with new before the pressure drops below 1 MPa (approximately 10 kg/cm^2G).

8-2 Periodic Checking and Service

Carry out the following periodic checking and service procedures once every six or twelve months.

a) Check all piping systems for clogging and soiling, cleaning if necessary.

b) Remove filters, pumps and solenoid valves, check and clean.

c) Empty the Pressure Relief Water Trap, clean it and then refill with clean tap water*.

Note: * See "8-1 Routine Maintenance Service," c)-1.

d) Check all tube connections and gas flow parts for leakage.

e) After completing the above service procedures, check the flow rate* to the Analyzer Unit and carry out zero/span calibration.

Note: * See "4-2 Warming Up," e) through m).

FLORIDA FIRST PROCESSING, L.P.

APPENDIX D-4-5

TOTAL HYDROCARBON ANALYZER

INSTRUCTION MANUAL
FLAME IONIZATION ANALYZER
F I A - 2 2 0 E N

HORIBA, Ltd.

Kyoto, JAPAN

Contents

1. OUTLINE

The FIA-220EN total hydrocarbon analyzer continuously measures total hydrocarbon concentration(FIA) in the gas discharged from the stacks of stationary sources and various buuurnt gases.Total hydrocarbon concentration is meaasured using a flame ionization detector.

The FIA-220EN Analyzer consists of an analyzer,a contorol unit and a signal prcessing unit in a compact 19" rack case,and it can measure a wide range of concentrations precisely.

BEST AVAILABLE COPY

2-1 FIA Operating Principles

(1) When a hydrocarbon is introduced into a hydrogen flame, the heat energy from combustion at the tip of the jet nozzle causes it to undergo ionization. If two electrodes are fitted on either side of the flame, and a DC voltage is applied between the two electrodes, this sets up a minute flow of ions which is proportional to the number of carbon atoms from the hydrocarbon. The current is converted to an electric voltage through resistor to detect hydrocarbon.

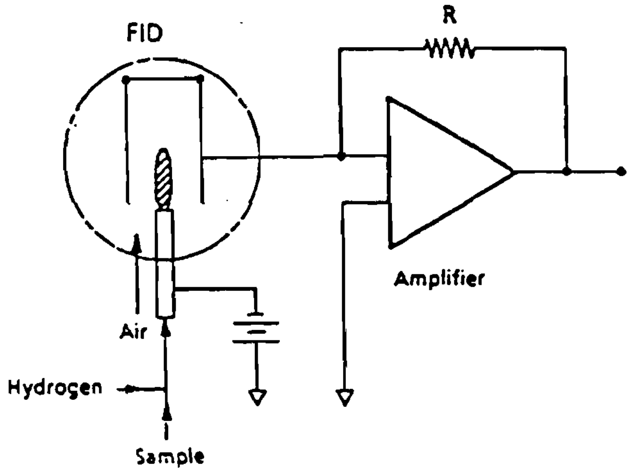


Fig. 1 Operating principles of the hydrogen flame ionization detector

(2) O_2 interference and relative sensitivity to different hydrocarbons

Measurements of hydrocarbon concentration taken using a hydrogen flame ionization detector are not affected by the presence of inorganic gases such as CO, CO_2, H_2O, NO, or NO_2 in the sample. However, changes in O_2 (oxygen gas) concentration do have an effect. This effect of this O_2 interference is very complex and varies according to many different factors.

Response to hydrocarbons is proportional to changes in concentration (number of carbon atoms) for a single hydrocarbon, but is not perfectly proportional to the number of carbon atoms in different hydrocarbons. This relative response of different hydrocarbons is called relative sensitivity.

The FMA-220 analyzer uses C_3H_8 (in air) as a reference for the relative sensitivity to different hydrocarbons. This allows accurate measurements to be made by keeping responses to within ±5% (including ±2% for gas accuracy) for a range of hydrocarbons.

Measurements also change according to factors such as flow rate, fuel components, proportion of fuel components, and detector structure (oxygen presence).

Test report showing the effects of O_2 interference (in C_3H_8) and relative sensitivity to a typical hydrocarbon are provided for reference.

3. INSTALLATION

3-1 Installation Conditions

(1) The analyzer is designed for use between 0 and 40°C.

(2) It should not be used if the relative humidity exceeds 85%.

(3) The analyzer should not be placed in a position where it may be heated by sunlight or by heat radiating from hot objects nearby. It should not be exposed to wind or rain.

(4) It should be used in a position where it is not affected by vibration.

3-2 External Connections

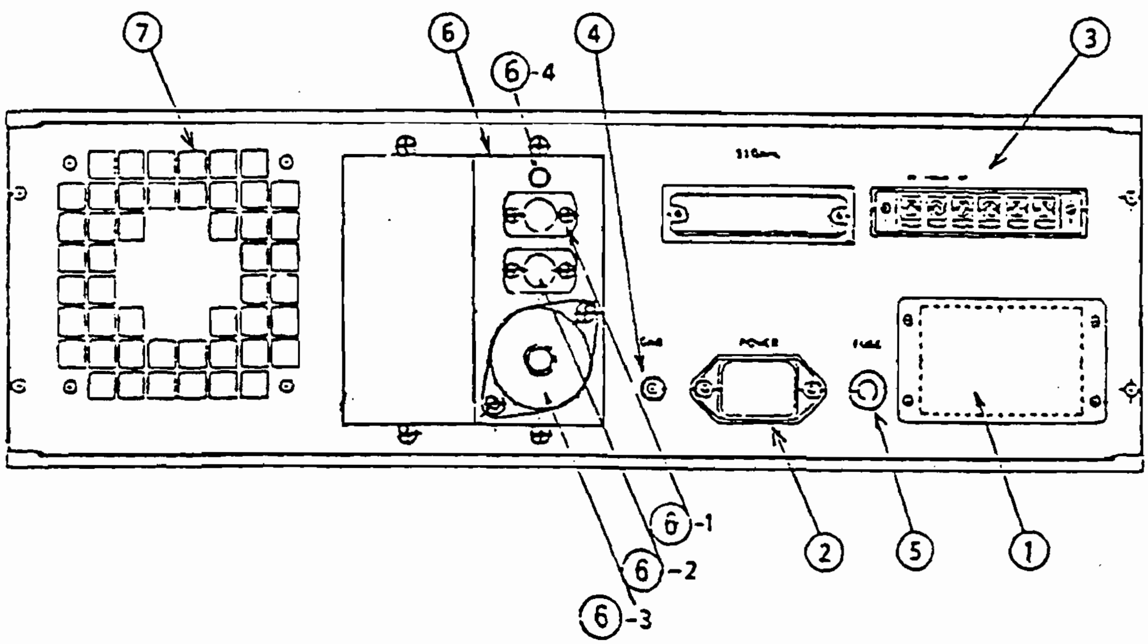


Fig. 3 Rear panel

① Option space

The option space port is 70 mm (width) × 40 mm (height).

② Power

This is the power supply (inlet) for the analyzer.

A 120V power supply is required. The analyzer should not be connected to the same power supply line as equipment likely to distort the voltage.

③ Signal output terminal boards

Each range has non-isolated synchronous outputs with analog output voltages between 0 and 100 mV and between 0 and 5V.

④ Ground terminal

The analyzer should be grounded with a green (wire) or green/yellow (mixed) spiral wire more than AWG18 connected securely to a point where the ground resistance is no more than 100Ω.

⑤ Fuse

A 5A standard size fuse should be used.

⑥ Piping connection

The standard piping interface has 1/8 NPT female screw. Four piping connections should be made.

(1) Stainless steel pipes (3/2 dia.) should be used for the FIA fuel,

(2) Teflon pipes should be used for all other piping.

(3) The outlet (bypass outlet) should use (ID) 7 or 8 mm reinforced vinyl tubes, connected so that there is no effect from back pressure. (⑥ – 4)

⑥ – 1 FIA Fuel inlet
– 2 FIA Burner air inlet
– 3 FIA Sample inlet
– 4 FIA Bypass outlet

⑦ Ventilation fan

The ventilation fan provides ventilation for the analyzer. The air outlet and the inlets on the sides of the analyzer must not be obstructed.

3-3 Checking The Installation

Before operating the analyzer, check the wiring and piping, the protective filter and the internal switch settings.

4-1 Control Panel

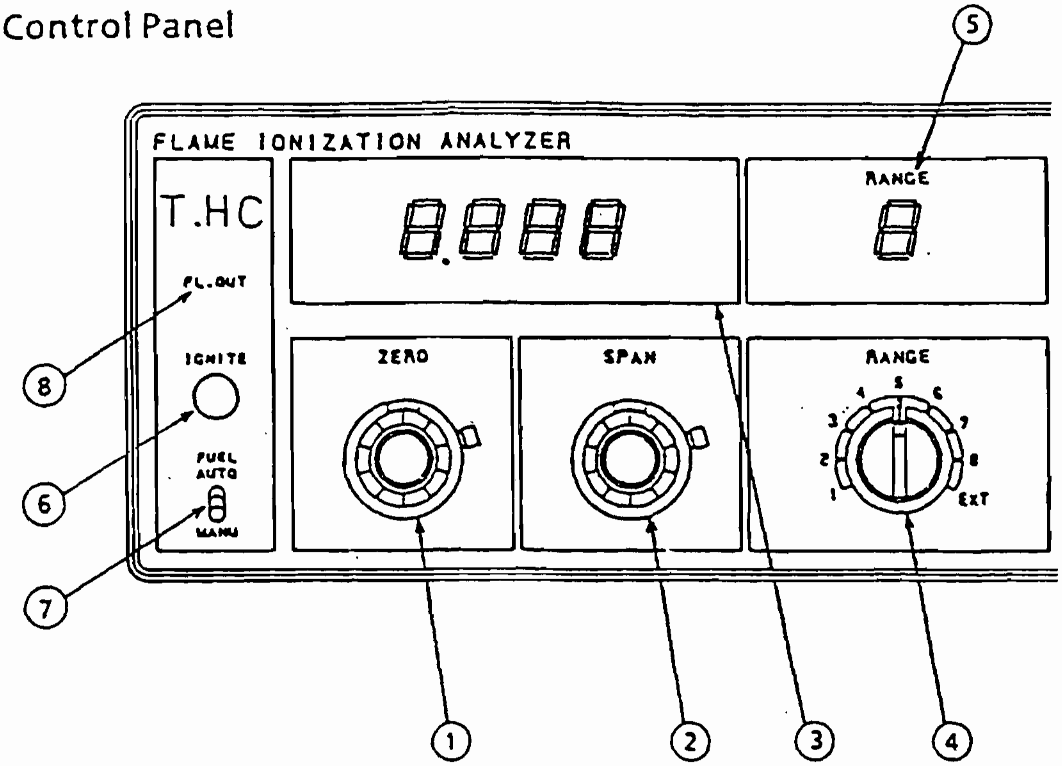


Fig. 4 FIA-220 control panel

① Zero control

The zero control is used to adjust the zero setting.

② Span control

The span control is used to adjust the span setting.

③ Digital display

The digital display shows the output voltage. (displayed as full scale 1V)

The display can indicate voltages up to ± 1.999V. When this range is exceeded, the ± 1.999V display flickers.

④ Range selection switch

The FIA measuring range switch allows up to 8 ranges.

Note: If all the ranges are not available, and the range switch is turned to a range number which is not in use (apart from EXT), the highest value among the available ranges is selected.

⑤ Digital range display

The digital range display shows the range being used by the analyzer.

⑥ Hydrogen flame ignition switch

This button is to ignite the hydrogen flame. The H_2 supply switch ⑦ must be set to MANU.

⑦ H_2 gas supply switch (auto/manual fuel line switch)

This switch is used to turn the fuel line on when igniting the hydrogen flame. Turn the switch to AUTO about 1 minute after the flame has ignited. When the switch is on AUTO, a protective circuit will automatically cut off the fuel line if the hydrogen flame goes out, and Alarm indicator ⑧ will light up.

⑧ Alarm indicator

The alarm indicator lights up if the hydrogen flame goes out.

(1) Connect the analyzer to the required power supply. (Refer to the name plate on the rear panel.)

(2) Use stainless steel pipes for the fuel and carrier N_2 gas connections, and teflon pipes for the other connections.

(3) Set up each gas line pressure as follows:

Fuel	: 150 ± 20kPa (1.5kg/cm^2 ± 0.2kg/cm^2) (FIA)
Air	: 150 ± 20kPa (1.5kg/cm^2 ± 0.2kg/cm^2) (FIA)
Carrier N_2	: 90 ± 10kPa (0.9 ± 0.1kg/cm^2) (MPA)

(4) Allow the analyzer to warm up for about 180 minutes after turning the power on.

(5) Supply the fuel gas and burner air, and turn the H_2 supply switch to MANU. Press the hydrogen flame ignition switch to ignit the flame.

(6) When the flame has ignited, turn the H_2 supply switch to AUTO. Allow the analyzer to warm up for approximately 2 hours with the zero gas flowing through it.

Note: There is a little noise when the flame first ignites, but this lessens when the analyzer stabilizes.

4-3 Calibration

When the analyzer has warmed up completely, make calibraiton the analyzer as described below before flowing in the actual gas to be measured.

(1) Zero calibraiton

Flow the zero gas into the analyzer and adjust the zero control until the display gives a reading of 0.

The zero gas should have a pressure of 30kPa (0.3kg/cm^2) and flow at approximately 2ℓ/min.

(2) Span calibraiton

Flow the span gas into the analyzer and adjust the span control until the display gives a reading which corresponds to the concentration of the span gas.

The span gas pressure and flow rate values should be the same as those for the zero gas.

4-4 Measurment

Flow the sample gas into the analyzer at the same flow rate as the compensation gas.

4-5 Measurment Completed

(1) Turn out the FIA hydrogen flame as follows.

① Close the valve of fuel gas cylinder and so stop the fuel gas.

② The flame goes out when the fuel gas supply stops. FL.OUT lights up on the control panel to confirm that the flame has gone out. (This alarm indicator lights up within 1 minute of the flame going out.)

③ Continue to supply burner air for about 10 minutes after the flame has gone out for purging. The burner air can then be stopped.

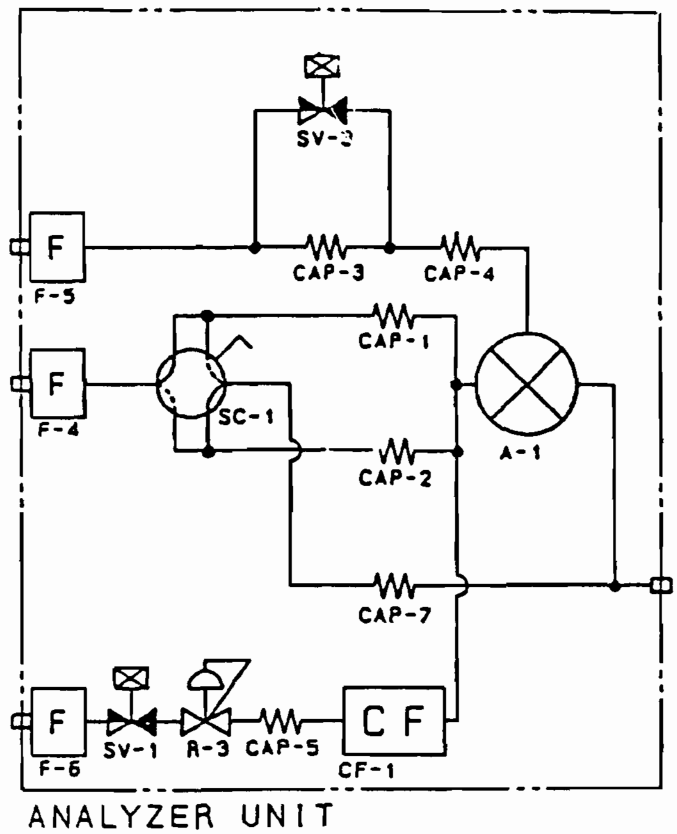
Note: Turning the power off with the flame still alight may cause isolation defects in the detector, so it should be avoided unless absolutely necessary.

(2) Finally, turn the power off. Unless the analyzer is to remain switched off for a long period, the bench power supply should be left on if possible.

5. CONSTITUION

5-1 Flow Schematics

(1) FIA



①Pressures and standard flow rates

		(Reg specifications)
Regulator (Reg3):	80kPa (0.8kg/ cm²)	UA12-S802-AV
		(Cap specifications)
Capillary(Cap1) :	Approx.6ml/min	SA-500
Capillary(Cap2) :	APprox.6ml/min	SA-500
Capillary(Cap3) :		SA-301
Capillary(Cap4) :	400ml/min	SA-S551GJ
Capillary(Cap5) :	20ml/min	SA-060-RJ
Capillary(Cap7) :	Approx.500 ml/min	SA-551GJ

5-2 Configuration

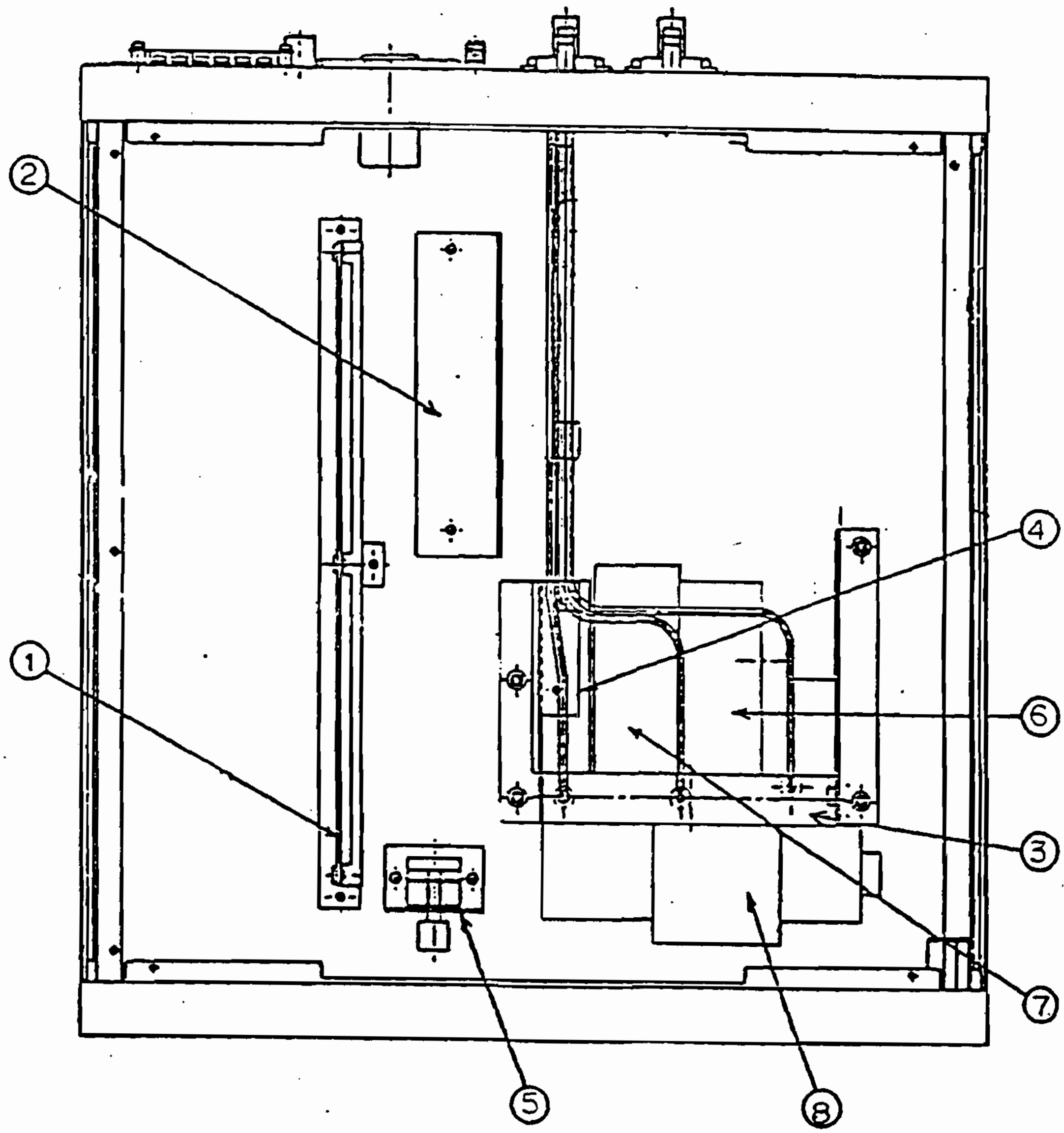


Fig. 8 Top view

No.	Parts Name	Reference	(Model)
(1)	FIA mother board	――――	――
(2)	Switching power supply Nozzle heater power supply	+5V DC, ±15V DC, +12V DC +24V DC Approx.50W	URSS-254H
(3)	FIA pattern(THC)	Atainless steel(described in detail below)	――
(4)	Bench temperature controller	FIA	TC-150
(5)	Maintenance switch	(described in detail below)	

<Note>

Maintenance swich(5)

The maintenance swich is used to check the basic internal power supply voltages.

MEAS :Normal measurement.The maintenance swich should be set to this position for normal use.

+15V :Amplifier power supply voltage
+1.500V(+15V DC)

-15V :Amplifier power supply voltage
-1.500V(-15V DC)

+24V :Power supply for amplifier relay and internal solenoid valves
+0.240V(+300V DC)

HV :HV applied voltage for the FIA
-0.300V(-300V DC)

Power swich

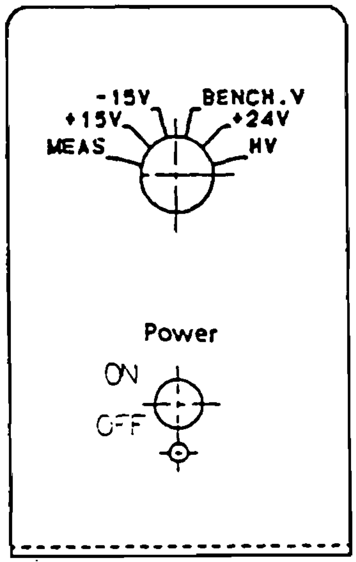


Fig.9
Maintenance swich

(6)	FIA chimney		――
(7)	Box for discharge igniition board	FIB-02	――
(8)	Capillary temperature contoroller box(FIA)		――

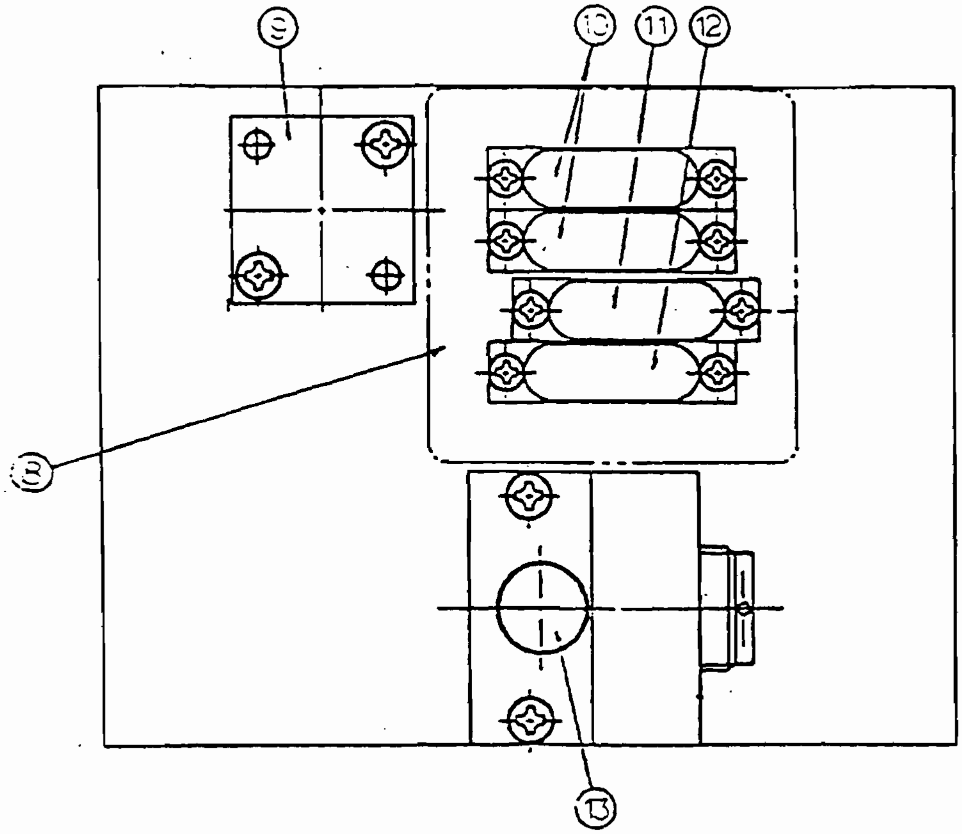


Fig. 10 FIA internal components (front)

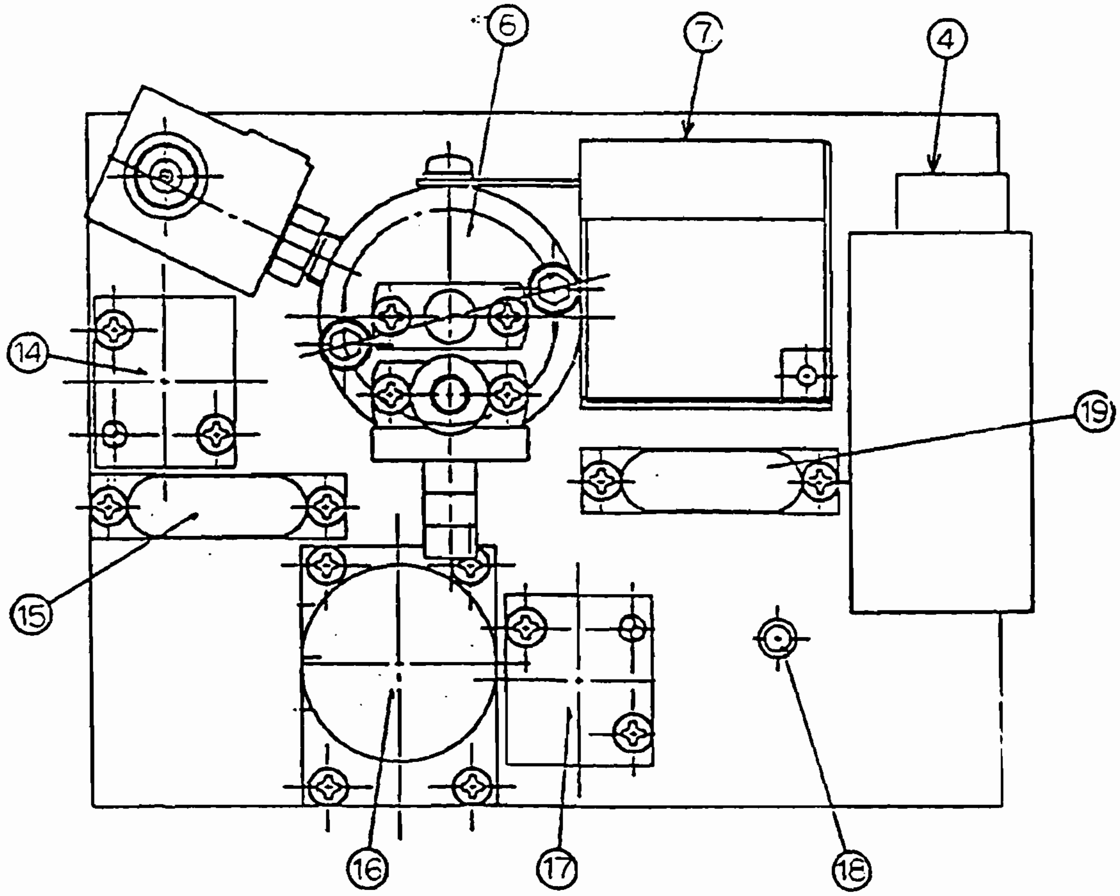


Fig. 11 FIA internal components (rear)

No.	Parts Name	Reference	(Model)
(9)	Six-way valve	Switches the line between sample Cap1 and sample Cap2. Cap2 shoud be used as a spare capillary.	———
(10)	Sample capillaries:Cap1,Cap2		SA-060S-BJ
(11)	Burner air capillary	Cap4	SA551GJ
(12)	Fuel capillary	Cap5	SA-060-RJ
(13)	Fule regulator	Reg3	UA12-5802-AV
(14)	Ignition adjustment solenoid valve	SV-3	———
(15)	Ignition adjustment capillary	Cap3	SA-301
(16)	Activated carbon filter(CF-1)	———————	———
(17)	Fuel line solenoid valve	SV-1	
(18)	Bypass flow outlet	Connect to a Bypass outlet (⑥-4)	———
(19)	Sample fow control capillary	Cap7	SA-551-GJ

6. ADJUSTMENT

6-1 Adjusting the FIA Amplifier System (See the mother board circuit diagram)

Ⓐ Operational amplifier offset adjustment

(1) Adjusting IC19 (E250) operational amplifier
With the [BG] switch on, adjust [A-Z1] with the input open (remove BNC connector) so that [TP1] is within ±0.4mV.

(2) Adjusting IC21 (151C) operational amplifier
Same status as in (1) above, adjust [A-Z2] so that [TP2] is within ±0.4 mV.

(3) Adjusting IC13 (151C) operational amplifier
Same status as in (2) above with [OFF] volume knob, adjust [TP3] to within ±1 mV.

Ⓑ Range ratio adjustment
In general, the intervals between the ranges are adjusted by adjusting each range independently using a gas with a concentration equivalent to the full scale for that range. The table below shows which adjuster corresponds to which range.

Range No.	Adjuster (VR)
Range 1 (× 1)	[GAIN]
Range 3 (× 10)	[RL]
Range 5 ($\times 10^2$)	[RM]
Range 7 ($\times 10^3$)	[RH]

Ⓒ Adjusting the flame alarm (FLOUT)
The flame alarm monitors the FIA hydrogen flame temperature and generates an alarm signal which is displayed on the control panel. The alarm is adjusted by adjusting the temperature at which the alarm signal is generated. Adjust [FLAME] so that the alarm signal is generated approximately 30 seconds after the hydrogen flame goes out.

Ⓓ Background check switch
This switch should be turned on when inspecting the FIA Background value.
Otherwise, it should be turned off.

Ⓔ Amp Gain Adjustment

(1) Let the span gas flow out and adjust the VR1 volume knob on the front panel board (PNB-01) so the front panel display reads
Front Panel Display = analog voltage output × 1000/5 ±3 count
with respect to 0-5V analog voltage.

(2) Adjust the SPAN volume knob on the front panel so the front panel display reads 1,000 at full scale. If it is way off, adjust the [GAIN] volume knob on the mother board to match.

MEMO.

6-3 Adjusting (Measuring) the Flow Rate Pressure

(1) Measuring the flow

① Flow rates are measured with a soap film flowmeter.

② Connect the soap film flow meter to the chimney outlet.

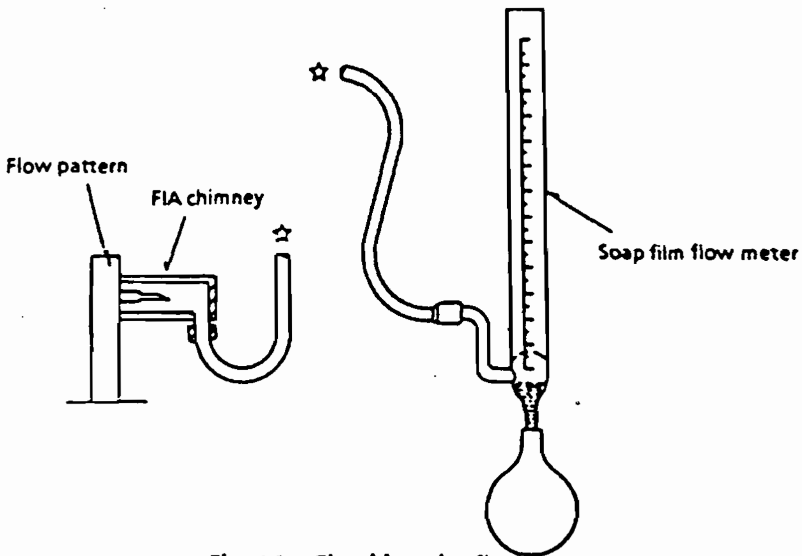


Fig. 14 Checking the flow rate

③ When checking FIA flow rates, check the burner air line flow first, and then the fuel line flow. Refer to the flow sheet in 6-1 for the standard Reg. pressure.

④ When checking MPA flow rates, connect the flow meter to 6-2-(37).

⑤ When measuring the sample flow rate at the FIA, R-2 (FIA) should be blanked off.

(2) Adjusting the Reg. pressure

① Connect a pressure gauge to the pressure check port.

Note: A special adaptor is required.

② As shown below, use a rod to turn the knob to the required voltage.

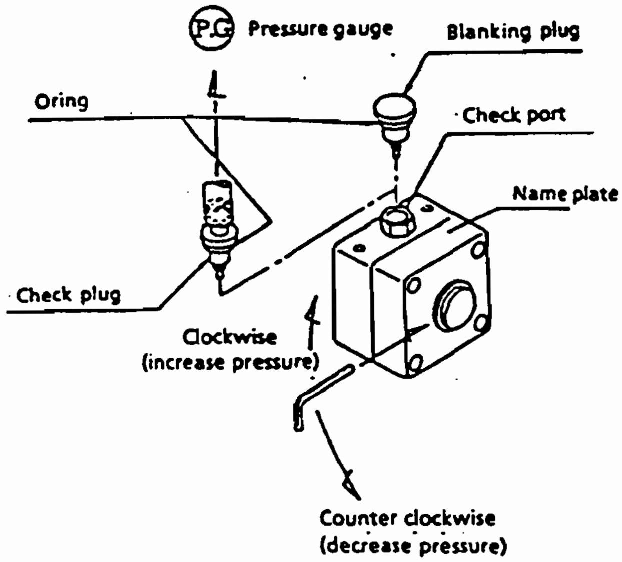


Fig. 15 Checking the pressure

(3) Cleaning the sample capillary

When the analyzer is used, the capillary slowly blocks up. If cleaned before it blocks up completely, it can become almost as good as new again.

Note: *Some contaminants may prevent the capillary from returning to its initial state. Clean the capillary by reducing the pressure at one end with a pump, and allowing an organic solvent (example: acetone) to flow through the tube. (Dip one end of the capillary in and out of the solvent.)*

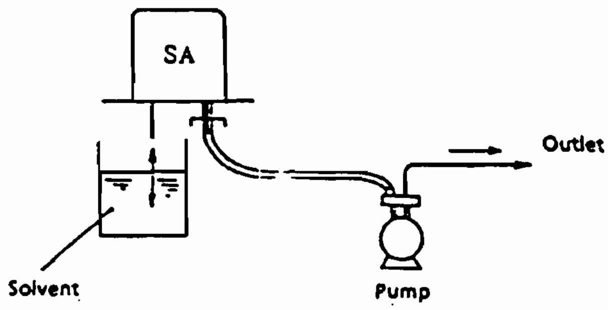


Fig. 16 Cleaning the capillary

In general, we recommend that the inside of the sample capillary is cleaned once every three months.

7. MAINTENANCE AND INSPECTION

7-1 Regular Inspection (Checking the Gas System)

Assuming sufficient pre-processing, the filter (10μ) on the sample gas inlet should be checked once every six months to make sure that it is not blocked.

Analyzer capillaries should be cleaned regularly as described in 6-3.

If a problem occurs with your analyzer, you should contact your service engineer. The symptoms and actions described below are just a general guide and are not exhaustive.

(1) FIA

Symptom	Cause	Action
① Ignition fault	ⓐ Electrical fault	• Inspect, repair or replace FIB-02A • Refit insulation shielding
	ⓑ Faulty ignitor	• Check the discharge spark • Replace the ignitor if the circuit is broken
	ⓒ Gas system fault	• H_2 is not flowing 1) Check action of SV-1 2) Check flow at Cap5 3) Check Reg3 gauge pressure • Insufficient burner air 1) Check action of SV-2 2) Check flow at Cap3 and Cap4 • Leaks from H_2 or burner air gas paths 1) Check paths and connections for leaks (Use detectors rather than soap solution wherever possible) • Inspect the nozzle for blockages
② Noise and fluctuations	ⓐ Electrical fault	• Detector insulation fault 1) Dismantle the detector • Faulty signal line or insulation 1) Inspect the signal line 2) Faulty shielding between signal line joints • Heater insulation fault 1) Replace (insulation should show at least 50MΩ resistance on a 1000V DC Megger.) • Poor temperature adjustment 1) Inspect the thermistor 2) Inspect the temperature adjustment circuit
	ⓑ Gas system fault	• Poor pressure adjustment at Reg.1 or Reg.4 1) Dry, dismantle and clean or replace • Inspect each gas path for leaks • Pump pulse or flow rate insufficient 1) Dismantle and clean or replace • Inspect capillary flow rate 1) Inspect the flow at Cap1, Cap2, Cap3 and Cap4

Symptom	Cause	Action
③ Insufficient sensitivity	ⓐ Capillary fault ⓑ Outlet line fault ⓒ Electrical fault	Inspect flow at Cap1, Cap3, and Cap4 • Poor adjustment 1) Insufficient capacity due to pump deterioration 2) Inspect Reg. pressure adjustment 3) Inspect each line for blockages • Faulty reed relay insulation: replace • Inspect for faulty contact between nozzle and H.V
④ Deviation from sample line indication	ⓐ BG difference ⓑ Line leakage ⓒ Capillary fault	• Inspect each gas path for leaks • Check the back pressure resistance on the bypass line
⑤ Flame sensor malfunction	ⓐ Sensor insufficiently sensitive ⓑ Sensor setting out of position ⓒ Flame circuit malfunction	1) Sensor detection electrodes touching earth 2) Replace the sensor See 6-1-ⓒ. • Circuit
⑥ Slow response	Capillary clogging	• Capillary clogging 1) Inspect flow at Cap1 and Cap2
⑦ Large drift	ⓐ Gas system fault ⓑ Electrical fault	• Faulty pressure regulator: dismantle and clean or replace • Activated charcoal filter line broken: reprocess • Poor temperature regulation 1) Inspect or replace the thermistor and temperature regulation circuit 2) Inspect the heater and temperature fuse • Faulty reed relay insulation: replace
⑧ Large deviations in output value linearity for high concentration ranges	Faulty contact between nozzle and HV	• Inspect and reassemble

Symptom	Cause	Action
⑨ Overshoot	ⓐ Residual high concentration gas ⓑ Contaminants adhering to piping	• N_2 gas purge • Gas purge or replace
⑩ Abnormalities with output linearity, oxygen interference, and relative sensitivity, etc.	ⓐ Capillary insufficient ⓑ Poor nozzle ⓒ Leaks ⓓ Poor pressure adjustment ⓔ Faulty flame sensor	• Inspect flow at Cap1, Cap2, and Cap3 • Inspect nozzle bore and fitting • Inspect the connections on each line for leaks • Inspect Reg1, Reg2

FLORIDA FIRST PROCESSING, L.P.

APPENDIX D-4-6

CONTINUOUS HCL ANALYZER

DURKIN EQUIPMENT COMPANY
P.O. Box 43
MARYLAND HEIGHTS, MISSOURI 63043-9043
(314) 291-0000

4

TESS-COM, INC. *Analytical Instrumentation*

P.O. BOX 600 • CLAIRTON, PA 15025 • (412) 233-5782 • FAX: (412) 233-8354

MODEL 745

CONTINUOUS HCL, HF AND F_2 GAS ANALYZER

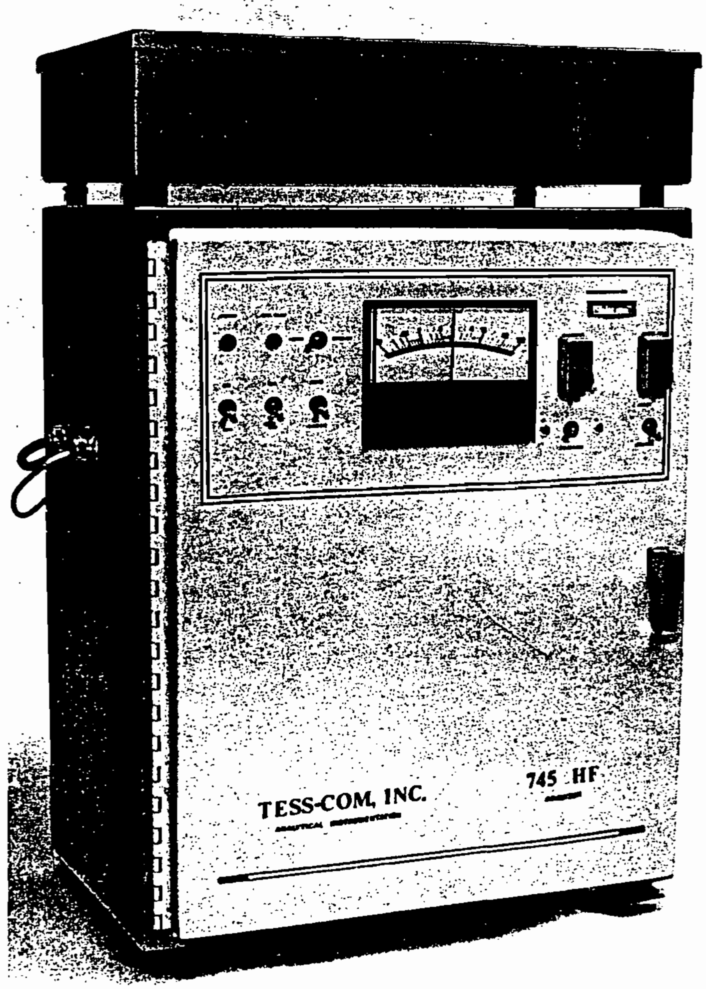
FOR

PROCESS

ENVIRONMENTAL

TOXIC GAS

SOURCE GAS



**E.P.A.
APPROVED**

MODEL 745 PROVIDES POSITIVE, SELECTIVE, REAL-TIME, CONTINUOUS MONITORING

INTRODUCTION

This monitor has been developed to provide continuous measurement of low concentrations of gaseous sample in ambient air with accuracies equal to or better than those obtained by conventional analytical techniques. Levels of concentration as low as .1 PPB are detected with results displayed on a large easily read meter and recorded permanently on a strip chart recorder. Interfacing to process control equipment is also possible.

Long term stability required for unattended operation is obtained by using high stability analog amplification, by thermostatting the electrode and by automatic restandardization. Electronic and mechanical design is simple and modular, so that reliability is maximized and servicing can be done with little more than a screwdriver and volt-ohmmeter.

PRINCIPLES OF OPERATION

Measurement: a gas sample is taken from ambient air using teflon tubing as the sampling line into a miniature cyclone separator to remove solid particles. The sample is then pulled into an aerosol gas scrubber by a teflon coated diaphragm vacuum pump. The gas flow rate is maintained constant by the entrance orifice of the scrubber. A metering pump introduces a constant flow of deionized water into the scrubber, and the gaseous sample is scrubbed in the water aerosol mist. A metered sample is delivered continuously to a mixing chamber where a constant amount of buffering reagent is added. This reagent fixes the pH of the sample to eliminate interference, and adds a fixed concentration of ions as a reference for the measuring cells. The sample then flows through a thermoelectrically cooled temperature block and past the surfaces of the fluoride measuring electrode and the reference electrode creating a potential difference corresponding to the ion concentration (activity). This voltage is fed to the high stability electronics package for amplification and processing to provide proper outputs for meter, chart recorder, and or process control equipment.

SAMPLING

In sampling sources containing particulates a filter should be used to remove large dust particles and is advisable when making measurements near dust sources. The analyzer in source range can continuously monitor gaseous emissions from stack outlets, inlets, and potroom roof monitors. With slight modification, the analyzer can be used to monitor ambient levels in community air. The analyzer is designed to serve as an integral part of plant environmental testing programs. A lower detectable limit of 0.1 PPB in air and an upper range of greater than 1000 PPM makes this unit a versatile environmental tool.

SPECIFICATIONS

PPB STANDARD RANGES

100 PPB
1000 PPB

PPM STANDARD RANGES

10 PPM
100 PPM
1000 PPM

DUAL OUTPUTS

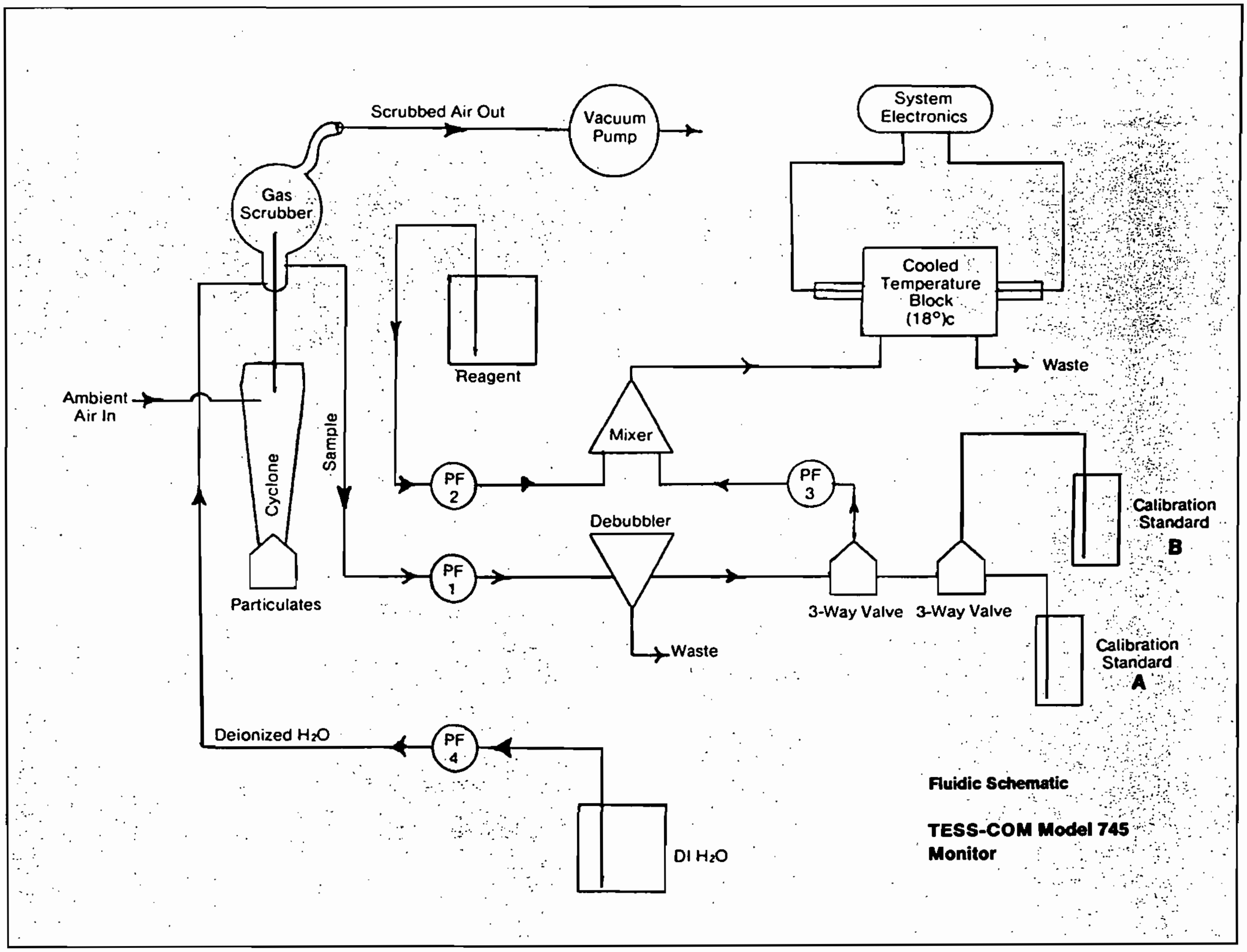
0-5Volts DC and 4-20 MADC
Isolated

POWER REQUIREMENTS

500 Watts, 115 Volts, 60 Hz
250 Watts, 220 Volts, 50 Hz

DIMENSIONS

HEIGHT	29" (736.60 mm)
WIDTH	20" (508.00 mm)
DEPTH	13" (330.20 mm)
WEIGHT	37 lb. (16.80 kg)



FLOW DIAGRAM

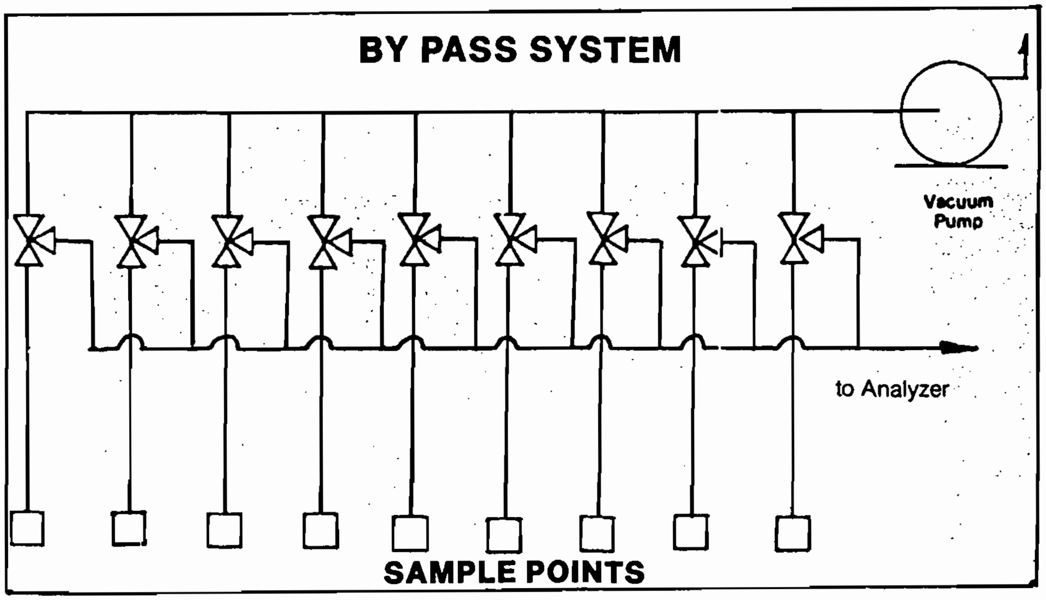
APPLICATIONS FOR HF, HCL, F_2

Stack Monitoring: Smelters, Incinerators, Scrubbers, Nuclear Fuel Enrichment UHF6, Fertilizer Industry, Ceramics Industry, Glass Industry, Process Control.

Ambient Monitoring: Environmental, PPB range for P.S.D. Permits, Compliance Monitoring.

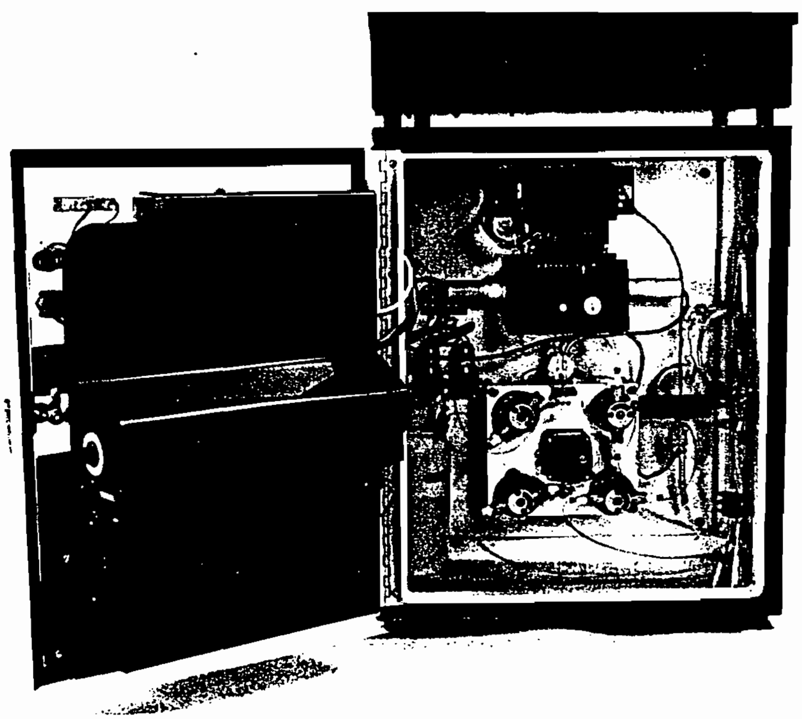
Toxic Area Monitoring: HF Storage areas, Process areas, Hydrofluoric Acid Manufacturing, HF Alkylation Units, Freon Manufacturing.

MULTIPOINT SAMPLING SYSTEM



An optional multipoint sampling system is available for monitoring more than one sample point.

A programmable Controller is used to sequentially activate the timing and duration of the opening of each solenoid valve. Individual alarm relays and analog outputs are provided for each sampling point.



KEY FEATURES

- AUTO CALIBRATION (Internal timer or computer Command)
- INTERNAL SLOPE CALIBRATION
- LOW RANGE PPB
- HIGH RANGE PPM
- NO EXTERNAL SAMPLE CONDITIONING REQUIRED
- ALARMS
- LOW COST TO OPERATE
- FOUR LOG SCALE
- DUAL OUTPUTS 0-5 VDC, 4-20MADC LINEAR
- VIBRATION AND SHOCK RESISTANT
- FIELD PROVEN RELIABILITY
- DOES NOT REQUIRE INSTRUMENT AIR
- EASY TO REPAIR ELECTRONICS — ALL PARTS LOCALLY AVAILABLE

TESS-COM, INC. *Analytical Instrumentation*

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18

INTRODUCTION

SECTION I. DESCRIPTION OF EQUIPMENT

The Tess-Com Model 745 Gaseous Hydrogen Chloride Analyzer is a precise, accurate and reliable automatic real-time monitor. Years of experience with this equipment have led to the development of an instrument with a remarkable dynamic range and an operating up-time of over 90%. The effect of temperature is eliminated by thermostatting the sample chamber. Flow is controlled very accurately and precisely with a positive displacement pump. Ionic strength and pH are adjusted with a special reagent. Electrode reliability is checked by automatically restandardizing the instrument daily.

The patented Alcoa Aerosol Scrubber (U.S. Patent #3,960,523) provides efficient scrubbing of the gaseous sample, precise yet simple flow rate control, a uniformly mixed sample and a very easy-to-maintain scrubber.

The electronics package of the instrument has proven to be highly reliable. Long-term stability required for unattended operation is obtained by using high stability analog amplification, by thermostatting the electronics, and by automatic daily restandardizing of the system. Electronic and mechanical design is simple and modular; servicing of the instrument can be done with little more than a screw-driver, adjustable wrench and volt-ohm meter.

SECTION V. INSTRUMENT OPERATION

V-A. MODES OF OPERATION

AUTOMATIC

This mode of operation is slightly different for the Ambient Monitor and the Source Monitor. Ambient Monitor operating conditions will appear first followed in parenthesis by the Source Monitor Conditions.

In the automatic mode, the sample is pumped through the measuring chamber and analyzed for about 22-1/2 (23-1/2) hours out of 24, then the system calibration is checked with an internal standard solution and the monitor is automatically recalibrated.

During the automatic recalibration cycle, the 3-way valve is activated so that standardizing solution is pumped through the measuring chamber. After approximately 90 (30) minutes, the valve is switched so that sample is again pumped through the monitor. While standard is still in the measuring chamber and in the tubing leading to the measuring chamber, the automatic calibration motor is activated, driving the automatic calibration potentiometer until the needle is brought back to center scale or any other convenient point set on the meter. The percentage of available automatic calibration potential which has been used at any particular time is indicated on the restandardization meter.

MANUAL

In this mode, sample is pumped through the measuring chamber continuously unless overridden by the Check/Normal operation switch. Automatic recalibration does not occur. The timing cycle for automatic recalibration is unaffected and the restandardization meter reads zero. This mode of operation should only be used when 24 hours of uninterrupted data collection is absolutely essential.

CHECK MODE

In the check mode, the restandardization valve is switched so that calibration standard, rather than sample, is fed to the measuring chamber, whether the monitor is in manual or automatic operation. Use of the Check/Normal operation switch has no effect on the timing cycle for automatic operation.

STANDBY MODE

In the standby mode, the monitor is held in operational readiness without reagent consumption. The reagent pumps are OFF. The constant temperature assembly, timer, and amplifier will remain ON.

NOTE: Even though the analyzer is left in the stand by mode, the calibration timer will continue to advance and proceed through the calibration cycle. At the completion of the calibration cycle, the analyzer will return to the standby mode.

V-B. START-UP PROCEDURE

1. Insert the intake tube from the the #4 and #2 pumps into a gallon of deionized water.
2. Insert the shorting straps into the amplifier jacks.
3. Insert the electrodes into the control temperature assembly (See Section V-D-3a).
4. Set the following switch positions:

   Main Power ------------ on

   Manual/Auto ----------- manual

   Check/Normal ---------- normal

   Standby/Normal -------- normal

   Auto Cal Bias --------- off

   Vacuum ---------------- off
5. Perform an electronic check (See Section VI-B).
6. Perform a fluids check (See Section VI-C).
7. Turn off the main power. Replace the shorting straps in the connectors under the electronic module with the electrode jacks. The bromide electrode uses the front connection and fluoride the rear.
8. Remove the intake tube of the #2 pump from the deionized water and insert it into five gallons of fluoride buffer reagent (See Section IV-E).
9. Place a calibration standard in the standard solution bottle (See Section IV-E).
10. Set the following switch position:

    Main Power ----------- on

    Manual/Auto ---------- manual

    Check/Normal --------- normal

    Standby/Normal ------- normal

    Auto Cal Bias -------- off

    Turn Vacuum ---------- on

11. Allow at least six hours for the electrodes to reach temperature.

12. Calibrate the instrument (see Section V-C)

13. In twenty-four hours, check the calibration.

V-C-1. INTERNAL CALIBRATION PROCEDURE

There are two points of monitor calibration. One is to set the restandardization point at the center of the scale of the concentration meter. The second is to set the restandardization point at a position off-center. In both methods, a manual calibration is made before switching to the automatic mode. The center scale calibration procedure for the ambient monitor will be described. If off-center calibration is desired, contact Tess-Com, Inc. If the calibration procedure is being performed with new electrodes, or after the constant temperature assembly has been off for more than two hours, allow four hours for the electrodes to reach complete temperature equilibrium. Run a standard through the monitor to achieve this equilibrium.

EXAMPLE:

Center Scale Calibration

Mix two calibration standards. The second standard should be ten (10) times greater than the first.

Standard A: 1 ppm chloride (also used as an automatic recalibration standard)

Standard B: 10 ppm chloride (used as a slope standard)

1. Fill the standardizing solution bottle in the monitor with Standard A
2. Fill the solution B with Standard B.
3. Check to be sure that the tubing is deep into the solution bottles, or the air will be pulled into the pumps instead of the solutions.

4. Set switch positions as follows:

   Main Power - - - - - - - - ON

   Vacuum pump - - - - - - - ON

   Check/Normal - - - - - - - CHECK

   Manual/Auto - - - - - - - MANUAL

   Auto Cal Bias - - - - - - OFF

   Standby/Normal - - - - - - NORMAL

   Standards Switch - - - - - TO A

5. Standard A is now being pumped through the monitor. Wait for the system to come to equilibrium (no change in output reading for 10 minute time period).

6. Unlock the calibration control knob by moving its locking lever to the left. Adjust this control to set the needle on the concentration meter to center scale. Move locking lever to the right to lock control setting. Note and log the number on the calibration control for records.

7. Set the Standards switch to B. Standard B is now being pumped through the monitor. Wait for the system to come to equilibrium.

8. Unlock the slope control and adjust this control for a reading of 10 on the concentration meter. (This corresponds to the concentration ratio of Standard B as being 10 times greater than that of Standard A.) Note and log the number on the slope control for records.

9. Switch to the A position. Wait for equilibrium. The concentration meter should now read center scale. If not, repeat above procedure, starding with step 6. When calibration is completed, switch Check/Normal switch to Normal. THE CALIBRATION SWITCH MUST BE IN THE A POSITION.

10. Set the Manual/Auto switch to Auto.

11. Slowly turn the timer advance on the reverse side of the front panel to 90% on the dial.

12. Turn the Check/Normal switch to normal.

13. Slowly turn the timer advance until the check light comes on and stays on. This is the start of the restandardization cycle. Leave the timer in this position for five minutes. Slowly advance the timer until the check light goes off. The servo motor will set the concentration meter to center scale.

14. Timer - Set the timer advance to calibrate at the time desired by using the following equation:

$$\text{Timer setting} = 100 - \left(\frac{\text{Time Desired} - \text{Time Now}}{24} \times 100\right)$$

Time Desired and Time Now are in military time.

15. The monitor will now automatically recalibrate once a day and will not need to be recalibrated for two or three months. However, if there is a large daily change (10 to 45%) recorded on the restandardization meter, recalibrate and reslope the monitor manually.

V-C-2. FLOW RATE CALIBRATION PROCEDURES

The Model 745 Tess-Com Fluoride (or HCL) Analyzer operates on the principle of scrubbing a known volume of gas into a known volume of liquid. This is the reason that the gas flow rate and liquid flow rate must be calibrated. The calibration procedures are outlined on the next page.

Calibration Procedure for the Model 745HCL Analyzer when functioning as a stack analyzer using standard certified gases.

Environmental agency generally requires that the analytical analyzers shall be checked as a complete system, this means that the calibration standards must follow the same path through the system as does the stack sample in order to meet this requirement the injection of standards are to commence at the probe assembly on the stack. Via a three way valve ahead of the primary heated filter, a separate line from the zero and span cylinders must be used to transport these gases to the 3 way valve at the probe assembly.

1. Allow the analyzer to warm up for approximately 4 hours.
2. Set the switches on the analyzer in the following positions:

   Standby Switch..........On

   Bias Switch.............Off

   Check/Normal............Normal

   Manual/Auto.............Manual

   Standards ....to A

3. TURN ON zero standard (N2 Or Air) set regulator for approximately 15 lbs., allow analyzer to stabilize, since this gas contains no HCL the analyzer meter will go to a low point, make no adjustments turn off gas flow. Proceed to next step.
4. Using a calibration gas of 10 PPM HCL in a background of N2, set regulator for approximately 15 LBS, allow analyzer to stabilize, unlock calibration potentiometer set meter to coincide with the calibration standard, turn off cylinder.
5. To set upper range use a certified cylinder of HCL in a background of

N 2 10 times greater than the low range, turn on this cylinder set regulator for approximately 15 lbs, allow analyzer to stabilize, unlock the slope potentiometer adjust so that the meter coincides with the certified cylinder.

6. Repeat step number 4, instrument is now manually calibrated by gas phase.

7. SET Auto/Manual switch to the auto position.

NOTE: This analyzer is equipped with an internal auto calibration system. Using liquid standards as the reference method, this method is approved by the Federal E.P.A. and has N.B.S. tracability.

8. Set switch positions as follows:

   Main Power..........ON

   Vacuum Pump.........ON

   Check/Normal........check

   Manual/Auto.........manual

   Auto. Cal Bias......off

   Standby/Normal......normal

   Standards Switch....to A

9. Standard A is now being pumped through the monitor. Wait for the system to come to equilibrium (no changed input reading for 10 minutes tie period).

10. Unlock the calibration control knob by moving its locking lever to the left. Adjust this control to set the needle on the concentration meter to center scale. Move locking lever to the right lock control setting. Note and log the number on the calibration control for records.

11. Set the Standards switch to B. Standard B is now being pumped through

the monitor. Wait for the system to come to equilibrium.

12. Unlock the slope control and adjust this control for a reading of 100 on the concentration meter. (This corresponds to the concentration ratio of Standard B as being (10) times greater than that of Standard A. Note and log the number on the slope control for records.

13. Switch the calibration switch to A. Wait for equilibrium. The concentration meter should now read center scale. If not, repeat above procedure, starting wit Step 10.

14. Set the Manual/Auto switch to auto.

15. Slowly turn the timer advance on the reverse side of the front panel to 90% on the dial.

16. Turn the Check/Normal switch to normal. Set cal switch to A.

17. Slowly turn the timer advance until the check light comes on and stays on. This is the start of the restandardization cycle. Leave the timer in this position for five minutes. Slowly advance the timer until the check light goes off. The servo motor will set the concentration meter to center scale.

18. TIMER - Set the timer advance to calibrate at the time desired by using the following equation:

$$\text{Timer Setting} = 100 - \left(\frac{\text{Time Desired} - \text{Time Now}}{24} \times 100\right)$$

Time Desired and Time Now are in military time.

19. The monitor will now automatically recalibrate once a day and will not need to be recalibrated for two or three months. However, if there is a large daily change (10 to 45%) recorded on the restandardization meter, recalibrate and reslope the monitor manually.

For Preparation of Standards refer to the manual.

V-C-2a. WATER FLOW RATE CALIBRATION PROCEDURE

The recommended procedure for calibrating the Ambient Monitor Water Flow rate will appear first. Any differences for the stack monitor will appear in parentheses following the ambient procedure. A stop watch is required.

1) Fill a 50 ml (100 ml) volumetric flask with deionized (or distilled) water.
2) Set the following switch positions:

   Main Power ----------- on

   Check/Power ---------- check

   Auto Cal Bias -------- off (or on if in non-center calibration)

   Vacuum --------------- on

   Standby/Normal ------- standby
3) Remove the intake tube of the #4 pump from the water jerri can and insert the tube in the 50 ml (100 ml) volumetric flask.
4) Switch the Standby/Normal switch to normal and start the stop watch.
5) Stop the watch when all of the water has been pumped out of the volumetric flask.
6) Re-insert the line in the water jerri can. Switch the Check/Normal switch to normal.
7) Calculate water flow rate as follows:

Ambient	Stack
B = 50/t	B - 100/t

   where B = water flow rate in ml/min

   t = time in minutes
8) The water flow rate should be verified if; 1) the instrument is in initial set up; 2) a flow rate setting has been changed; 3) the #4 pump has been replaced; or 4) the seals on the #4 pump have been changed. Flow rates can be verified by repeating Steps 1 through 7.

V-C-2b. PROCEDURES FOR MEASURING AIR FLOW RATES

Procedure for measuring air flow using a calibrated rotometer:

1) Remove the sampling line from the inlet of the insert.
2) Attach a rotometer between the inlet of the insert and the sample line, record the reading. Remove the rotometer and re-attach the sample line.
3) Use the chart provided with the rotometer to convert the reading to standard air flow, read from the meter. Record this as q^0. In order to correct this for temperature and pressure, use the following equation:

$$F = q^0 \frac{Pb}{760} \frac{293}{T}$$

where: Pb - is the recorded barometric pressure at the time of the test, and

T - is the recorded temperature at the inlet to the nebulizers.

V-C-2c. PROCEDURE USING A MASS FLOW METER

1) Allow at least two hours for the mass flow instrument to warm up.
2) Since the flow F may now be measured directly, no P or t corrections for the device are needed.

Pressure and temperature corrections for the flow rate characteristics of the nebulizer.

The following equation can be used to calculate the nebulizer flow characteristics at standard conditions:

$$D^0 = F \frac{Pb}{760} \frac{293}{T_m}$$

where: D^0 is the flow rate at standard conditions

F is the measured flow at Pb and T_m

Pb is the barometric pressure in mm Hg.

T_m is the process or ambient temperature in ^{0}K.

NOTE: In computer controlled instruments, this calculation is performed automatically and continuously.

V-D. OPERATION OF THE INSTRUMENT

V-D-1. NORMAL OPERATION

Years of experience with the Model 745 Gaseous Fluoride (or HCL) Analyzer have led to the recognition of several indicators of a correctly calibrated, well running instrument. After a few days of experience with the instrument, the new operator should be able to determine at a glance whether the instrument is responding correctly. In order to accelerate this learning curve, some of these indications are specified in the following table:

TABLE I

Normal Operation recorder trace	- Smooth, noise-free trace.
Check mode recorder trace	- Smooth expotential rise or fall to the calibration
Restandardization meter	- Accumulated drift of less than 10% (normally less than 5%)
Concentration meter	- Response on the concentration meter and recorder agree.
Scrubber bulb	- Nebulizer delivering a fine mist; scrubber bulb clean with a smooth uninterrupted film on the sides; reservoir filled to the water outlet tube.
Cyclone (Ambient Monitor only)	- Cyclone clean.
Heated Sample Line	- Warm to the touch.

FLORIDA FIRST PROCESSING, L.P.

APPENDIX D-4-9

CORIOLIS MASS FLOWMETERS

Micro Motion Model D Mass Flow Meters

February, 1987

Instruction Manual

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Detailed Theory of Operation

Appendix II

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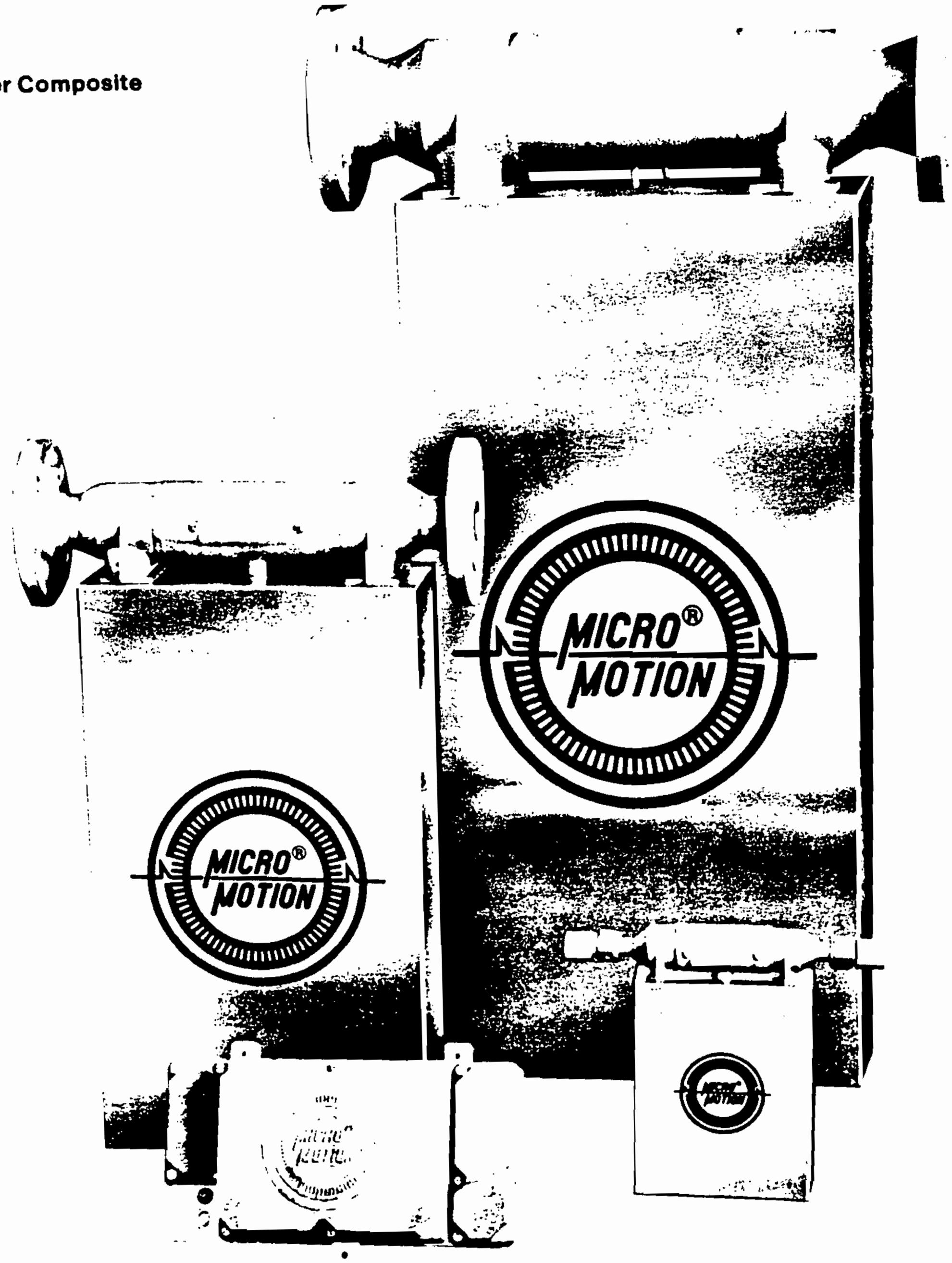
Figures

Figure 1
Model D Meter Composite



1 General Information and Specifications

1.1 General Information

All Model D mass flow meters, except the D6 and D12, consist of two obstructionless flow tubes in a stainless steel sensor housing connected to a remote electronics unit. The D6 and D12 sensor units are NEMA IV aluminum and contain a single flow tube. The sensor unit installs directly into any process and can be used in intrinsically safe installations. The remote electronics unit installs up to 500 feet from the sensor. The D Meter measures the mass flow rate of gases, liquids and slurries. Because it measures mass directly, problems associated with changes in fluid density, viscosity, temperature, and pressure are virtually eliminated.

1.2 Specifications

Table 1 shows the general specifications for the Model D Meter.

Table 1
Standard Specifications

Accuracy	± 0.4% of rate ± zero stability*
Operating temperature	-400°F to 400°F (-240°C to 200°C)
Electronics temperature	-40°F to 150°F (-40°C to 65°C)
Wetted parts	316L stainless steel**
Sensor housing	Hermetically sealed stainless steel***
Electronics housing	NEMA IV, polyethermide structural foam
Area classification**	
UL, CSA listed	Sensor: Class I, Group C and D, Class II, Division I; Class I, Division 2 Electronics: Class I, Division 2
BVS listed	Sensor: EEx ib IIB T4 Electronics: [EEx ib] IIB
Output signals	
Analog	0-20 or 4-20 mA, 500 ohm max load 0-5 or 1-5 VDC, 100K min. input or optional 0-50 or 10-50 mA, 200 ohm max. load 0-10 or 2-10 VDC, 100K min. input
Frequency	Signal: 0-15 volt square wave Max. output adjustable from 1.5 to 10,000 Hz for scaling engineering units Solid state switch: 30 VDC rating, 1 amp sink capability. or optional Isolated output, solid state relay, 500 Hz, 250 volt rating at 150 mA.
Response Time	Adjustable from 0.1 to 1.1 seconds or optional Adjustable from 5 to 6 seconds.
Power	100,115, 220 VAC ± 10%, 48 to 62 Hz or 12-30 VDC ± 15%; 8 watts

*Zero set at process temperature ± 20°F (± 11°C).
**Other wetted materials and fluid fittings are available, if required by your application. Contact your sales representative.
***D6 and D12 are NEMA IV Aluminum housings.
****Except D600.

1.3 D Meter Nomenclature

Table 2 shows the D Meter nomenclature. The information in Table 2 explains the coding used for the model numbers. Both the sensor unit and the electronics unit labels attached to the meter are coded.

To find the sensor model in Table 2, refer to categories I, II, and III, which appear on the sensor label in the following order: D(I)(II)-(III).

Category I describes the flow tube size. For example, if the code is a 6, the flow tube has a diameter of 1/16". The model number is commonly abbreviated by the model series and size code. The example just given would be referred to as a D6.

Category II designates the pressure rating of the flow meter sensor tubes.

Category III designates the type of wetted material used in construction of the flow tubes.

To find the electronics unit model in Table 2, refer to categories IV, V and VI, which appear on the electronics unit label in the following order: D(IV)(V)-(VI).

Category IV indicates the electronics design or approval.

Category V indicates the input power required.

Category VI indicates the type of output boards provided in the electronics unit.

Table 2
D Meter Nomenclature

Sensor Number D(I)(II)—(III)

I. Sensor Size

Code	Size
6	1/16"
12	1/8"
25	1/4"
40	.4"
100	1"
150	1.5"
300	3"
600	6"

II. Pressure Rating

Code	Rating
S	Standard pressure
H	Higher pressure

III. Wetted Material

Code	Material
SS	Stainless steel
HR	Halar* coated

*Halar is a trade name product of the Allied Corporation, Allied Fibers and Plastics Division.

Electronics Number D(IV)(V)—(VI)

IV. Intrinsically Safe

Code	Description
UL	UL approved
BV	BVS approved
CS	CSA approved
US	USA version
EU	European version
CA	Canadian version
RI	Japanese approved
AA	Australian approved
NI	Non-intrinsically safe

V. Power

Code	Power
115	115 VAC
220	220 VAC
100	100 VAC
VDC	12-30 VDC

VI. Output

Code	Output
AF	Analog-Frequency
AA	Analog-Analog
FF	Frequency-Frequency

1.4 Detailed Specifications

The specifications for the mass flow meters are defined below.

Flow Range. The flow range is stated in the pounds or kilograms per minute of flow each model size is designed to measure. The flow range limit of zero for every meter is based on the linearity of the meter at all flow rates within the range. The only limitations are the acceptable system pressure drop and the zero stability at very low flow rates.

Minimum Full Scale Flow. The minimum full scale flow is the lowest full scale flow rate for which the meter span select switch can be adjusted. Below this flow rate the meter cannot provide full scale output.

Maximum Full Scale Flow. The maximum full scale flow is the highest full scale flow rate for which the meter span select switch can be adjusted. It is the high flow range value.

Span. With reference to the Micro Motion mass flow meter, span may be defined as the ratio between the meter's maximum full scale output and minimum full scale output. The high flow range states the maximum full scale flow rate for which the span may be calibrated. Each mass flow meter has a 20:1 span.

Calibrated Maximum Full Scale Flow. The calibrated maximum full scale flow can be any value between the minimum and maximum full scale flow for a specific sensor size. This calibrated value is adjusted for the customer's flow rate by setting the span select switch for each individual meter at the factory. This calibration can be changed as needed. (See Chapter 5 for recalibration procedure.)

Rated Operating Pressure. The rated operating pressure is at least ¼ of the theoretical burst pressure of the material. The specifications give the rated pressure in pounds per square inch (psi) and bars. Meters with stainless steel wetted parts are UL approved up to the rated pressure.

Zero Stability. This is the output stability of a properly installed meter at zero flow. Although the flow rate signal remains linear to zero, at very low flow rates the accuracy is necessarily limited by the zero stability.

Accuracy. The accuracy of the Micro Motion mass flow meters includes bias error, repeatability, and zero stability. Since these errors are considered independent, they add by their square roots rather than being cumulative. Therefore, actual error will often be less than the 0.4% of flow rate ± zero stability stated in specifications. Repeatability is generally better than 0.1%.

Table 3 on page 4 shows some of the detailed specifications for each sensor size.

Table 3
Detailed Specifications

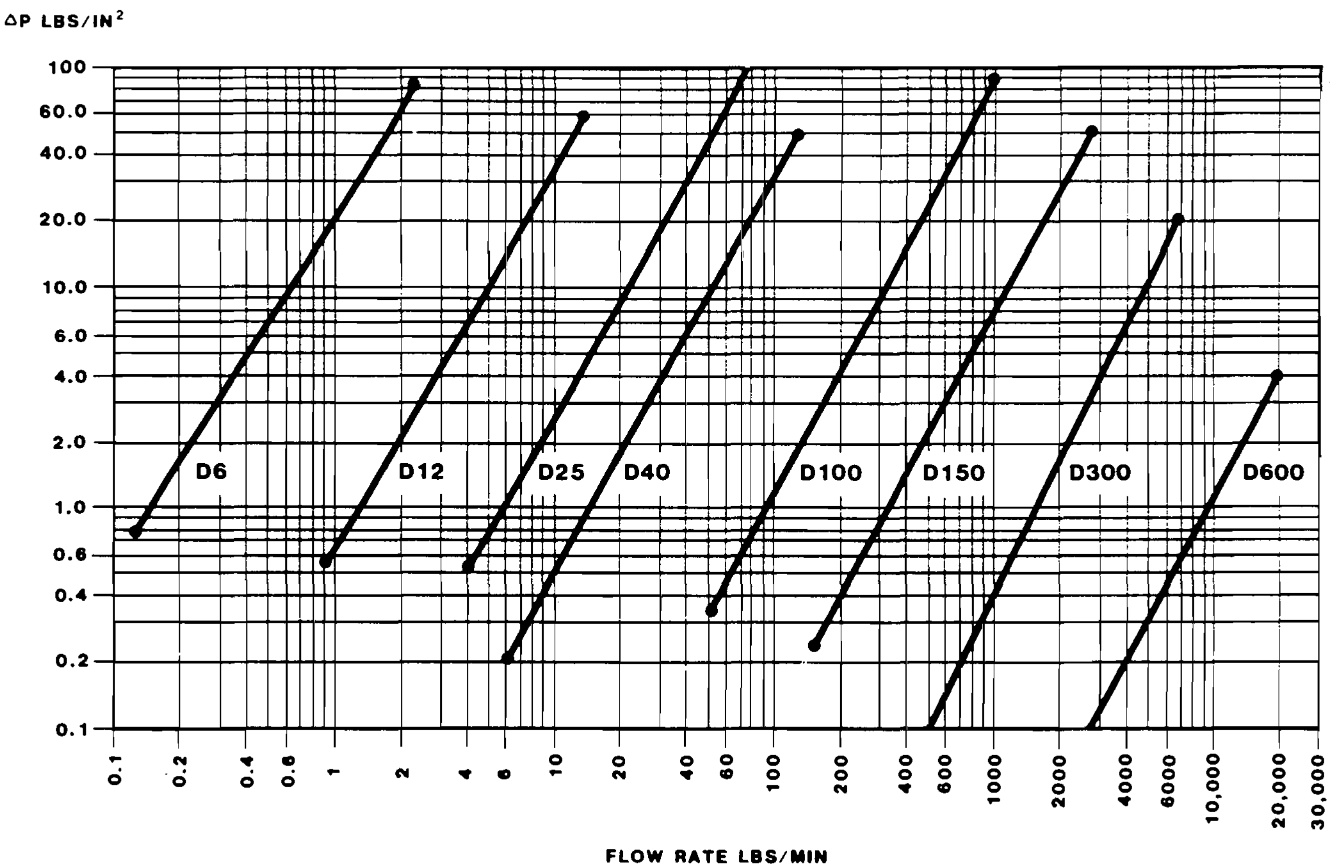
Specification	*Pressure Rating*	*Wetted Material*	*Units*	*Sensor Size* 6	12	25	40	100	150	300	600
Flow Range	S	SS	lbs/minute kgs/minute	0-2.0 0-.91	0-11 0-5.0	0-80 0-36	0-120 0-55	0-1000 0-455	0-2800 0-1270	0-7000 0-3180	0-20000 0-9090
	H	SS	lbs/minute kgs/minute		0-26 0-12	0-120 0-55	0-200 0-90	0-3000 0-1364	0-12000 0-5455	0-40000 0-18200	
	S	HR	lbs/minute kgs/minute						0-2800 0-1270	0-7000 0-3180	0-20000 0-9090
Minimum Full Scale Flow	S	SS	lbs/minute kgs/minute	.10 .05	.55 .25	4.0 1.8	6.0 2.7	50 23	140 64	350 159	1000 455
	H	SS	lbs/minute kgs/minute		1.4 .64	6.0 2.7	10 4.5	150 68	600 273	2000 909	
	S	HR	lbs/minute kgs/minute						140 64	350 159	1000 455
Rated Operating Pressure*	S	SS	psi bars	2600 179	1700 117	2800 193	1250 86	2250 155	1500 103	740 51	720 49
	H	SS	psi bars		3600 248	4000 276	2800 193	5600 386	5600 386	4000 276	
	S	HR	psi bars						1000 68	600 41	720 49
Zero Stability	S	SS	lbs/minute kgs/minute	.0002 .0001	.002 .001	.015 .007	.02 .01	.10 .05	.30 .15	.70 .32	2.5 1.1
	H	SS	lbs/minute kgs/minute		.004 .002	.022 .01	.04 .02	.30 .15	1.3 .59	4.0 1.8	
	S	HR	lbs/minute kgs/minute						.30 .15	[illegible] [illegible]	2.5 1.1

*Based on ANSI/ASME B31.3, at room temperature.
Commensurate with proper fittings.
Specifications subject to change without notice.

1.4.1 Pressure Drops

Table 4 shows the pressure drops for Model D Meters. This chart is valid for determining the pressure drop of process fluids with viscosities near 1 cp. For specific gravities other than 1, divide the plotted pressure drop by the specific gravity. (Specific gravity is based on water at 70°F.) For higher viscosities and gases, consult the factory or the sales representative.

Table 4
Pressure Drops



1.5 Fluid Fittings

Table 5 shows the fluid fittings available for the different sizes of meters. When connecting to Ladish fittings, pay careful attention to the actual tube sizes listed in the footnotes below the table.

Table 5
Fluid Fittings

Model	*D6*	*D12*	*D25*	*D40*	*D100*	*D150*	*D300*	*D600*
Cajon VCO w/NPTF adapter NPTF	¼" .25	¼" .25	⅜" .37	⅜" .37				
ANSI 150 lb flange* A150	½" .50	½" .50	½" .50	½" .50	1" 1.0	1½" 1.5	3" 3.0	6" 6.0
ANSI 300 lb flange* A300	½" .50	½" .50	½" .50	½" .50	1" 1.0	1½" 1.5	3" 3.0	6" 6.0
ANSI 600 lb flange* A600			½" .50	½" .50	1" 1.0	1½" 1.5	3" 3.0	
Ladish Tri-Clamp (304ss)** LDSH	½" .50	½" .50	½" .50	½" .50	1" 1.0	1½" 1.5	3" 3.0	6" 6.0
NPTM NPTM			½" .50	½" .50	1" 1.0	1½" 1.5	3" 3.0	
DIN PN 40 flange* DNPN	10mm 10m	10mm 10m	15mm 15m	15mm 15m	25mm 25m	40mm 40m	80mm 80m	150mm 150m
Cajon VCO w/JIS PT adapter JSPT	¼" .25	¼" .25	⅜" .37	⅜" .37				
JIS B 2212 flange* JS12	10mm 10m	10mm 10m	15mm 15m	15mm 15m	25mm 25m	40mm 40m	80mm 80m	150mm 150m
JIS B 2214 flange* JS14	10mm 10m	10mm 10m	15mm 15m	15mm 15m	25mm 25m	40mm 40m	80mm 80m	150mm 150m

*D6, D12 have Cajon VCO with flange adapter.

**For connection purposes, the outside diameters for the different sizes of Ladish mating faces (in inches) are: Size ½=.989, size 1=1.984, size 1½=1.984, size 3=3.579, size 6=6.570.

1.6 Operational Features

Each meter is equipped with the following standard features:

Remote Electronics Unit. The remote electronics may be mounted up to 500 feet from the sensor unit for installations where the meter is exposed to high temperatures, flammable gases, high pressure water baths, or for the operator's convenience.

Only one setup adjustment. The factory calibrates each meter, so only the external primary zero potentiometer must be adjusted after installation.

Reversible flow. The meter operates with full accuracy regardless of flow direction. The flow direction signal output is available for bidirectional flow.

Wide Flow Range. Although the factory presets the flow range for the customer's specifications, it may be easily field adjusted. The meter has a 20:1 span.

Adjustable Time Constant. The time constant potentiometer on the signal board damps erratic signal output caused by pumps, sudden vibration, or other incidental system noise. Factory preset to 0.3 seconds, this adjustment is easily modified to help ensure a stable control loop in analog feedback systems.

Choice of Outputs. Mass flow meter outputs are designated in the electronics model number as Analog-Frequency (AF), Analog-Analog (AA), or Frequency-Frequency (FF). The frequency board can output 10,000 Hz. The analog board provides a choice between milliampere and DC voltage outputs. The select switch allows 0-20 mA, 4-20 mA, 0-5 VDC, or 1-5 VDC.

Frequency Board Features.

Frequency Cutoff. For applications requiring a totalized flow, an adjustable low flow (1%) dropout prevents low-level noise from being converted into pulse signals and overbiasing the totalized amount.

Frequency Range Adjustment. Preset to customer specifications, the scaling of output pulses can be field adjusted to meet new metering applications or frequency interfaces.

Intrinsically Safe Operation. All D Meters are designed to be intrinsically safe. The D600 has both intrinsically safe and explosion-proof design features. The intrinsically safe sensor units listed in Table 3 have UL, CSA or BVS approval for the hazardous areas listed in Table 1. The remote electronics classification areas are also listed. Specific approval and area classification is stated on each meter tag.

The analog and frequency outputs are not intrinsically safe, and must have barriers if they return to the hazardous area.

1.7 Options

The following design options are available for specific application requirements:

Analog Output. An analog board with output choices of 0-50 mA, 10-50 mA, 0-10 VDC, and 2-10 VDC is available.

Isolated Frequency Output. A frequency board with an optically coupled output is available. This provides a fully isolated output, and the solid state relay in the circuit is rated to 250 volts at 150 mA. The maximum frequency is 500 Hz.

5-6 Second Response Time. A signal board with a 5-6 second response time is available rather than the adjustable 0.1 to 1.1 second time constant. The response time on this optional board is only adjustable between 5 and 6 seconds.

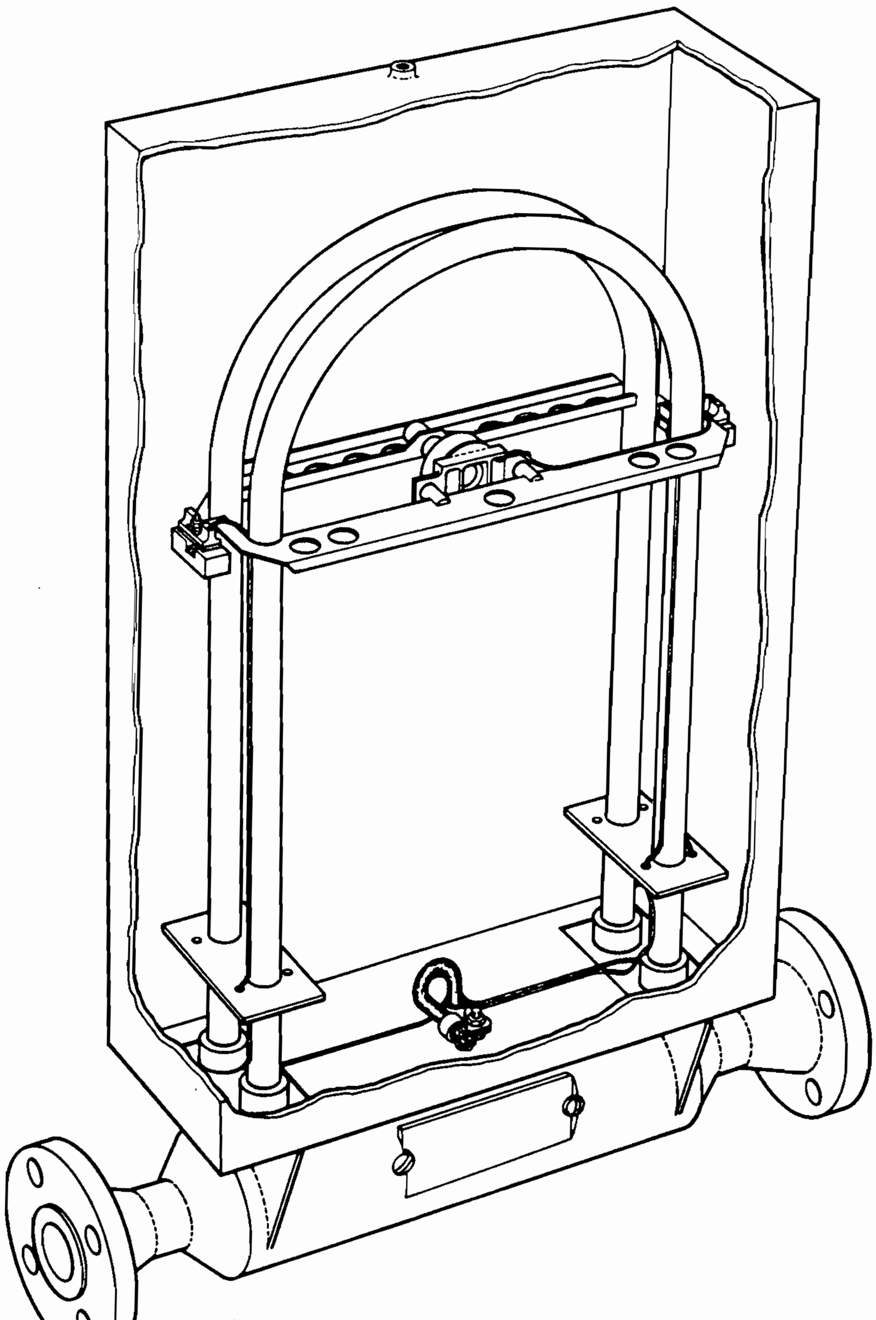
10% Frequency Cutoff. A frequency board with an adjustable 10% frequency cutoff rather than the standard adjustable 1.0% cutoff is available.

Corrosion Resistant Flow Tubes. For especially corrosive applications, the sensor tubes can be fabricated from more resistant materials than the standard 316L stainless steel, or on some models they can be lined with inert plastic.

Special Fluid Fittings. The meter can be equipped with a variety of sanitary, high pressure, or quick connect fittings, as well as the standard fluid fittings.

Special options, such as explosion-proof housings, remote switches for accessories, etc., will be quoted from the factory. For many specific metering needs, additional parts and accessories are available. Refer to Section 6.0, Replacement Parts/Accessories, for further information.

Figure 2
Sensor Unit Cutaway



2 Principle of Operation

2.1 Flow Meter Measures Mass Directly

The Micro Motion mass flow meter measures mass directly. Mass, along with the units of length and time, constitutes the basis for all physical measurements. As a fundamental standard of measurement, mass does not derive its units of measure from any other source. Variations in temperature and pressure do not affect mass. Such constancy makes mass the ideal property to measure.

Until recently, no practical method of measuring mass in motion existed. Users had to infer mass from other measurements, such as volume. Unfortunately, volumetric flow meters measure not mass, but the space it occupies (Figure 3). Therefore, one must calculate the effects of temperature and pressure on density when deducing mass from volume.

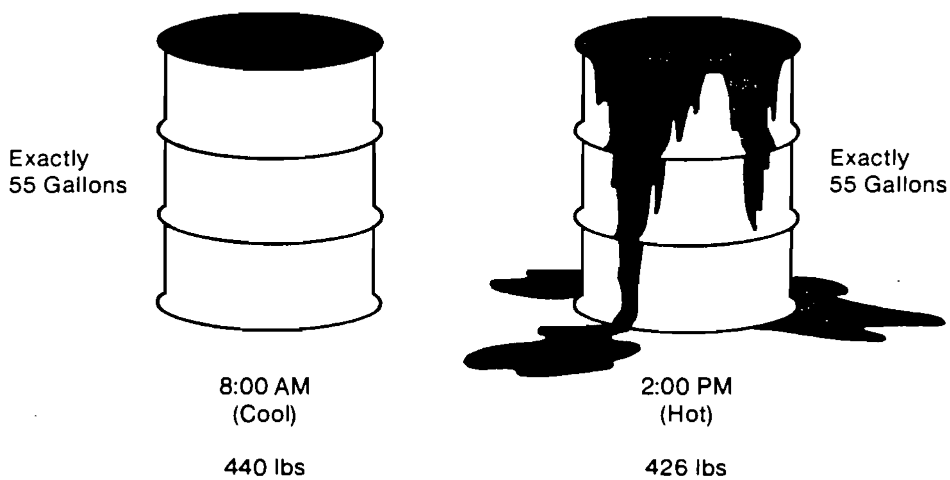
Direct mass flow measurement avoids the need for complex calculations. It deals directly with mass, and since mass does not change, a direct mass flow meter is linear without adjustment for variations in fluid properties.

2.2 General

The meter operates by application of Newton's second law of physics: Force equals Mass times Acceleration ($F = ma$). It uses this law to determine the exact amount of mass flowing through the meter.

Sections 2.3 and 2.4 provide the general theory of sensor and electronics operation. Appendix I provides a detailed explanation of the theory.

Figure 3
Inaccuracy of Volumetric Measurement



2.3 Sensor Unit

Figure 4 shows the flow tube assembly inside the sensor unit. Within the sensor housing, the drive coil, a magnetic device, converts the signal from the electronics unit into a force to vibrate the flow tubes. The tubes vibrate at their natural frequency in the same manner as a tuning fork. The peak amplitude is less than one tenth of an inch, and they complete a full cycle about 80 times each second.

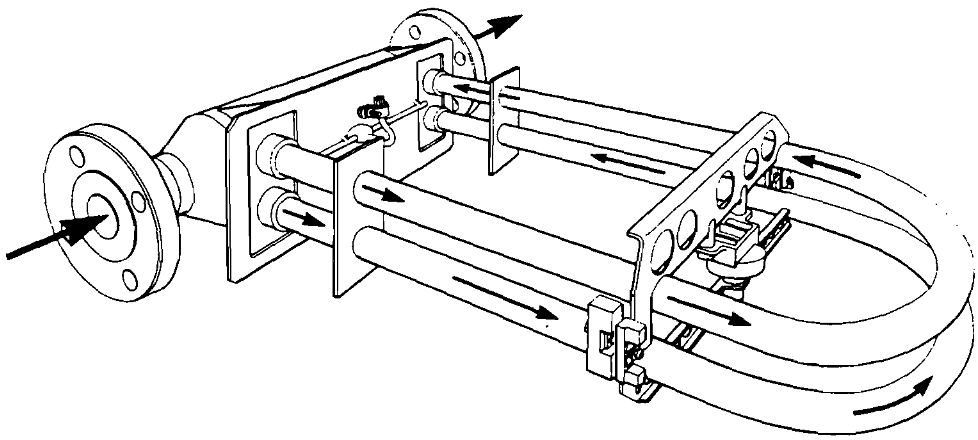
As fluid flows through the tubes, it is forced to take on the vertical movement of the vibrating tubes. The forces of the tube always oppose entering fluid and aid departing fluid. As the fluid accelerates on the inlet side and decelerates on the outlet side, it causes the tubes to twist.

The resisting fluid flow induces a Coriolis force on each side of the tubes. The twist caused by the Coriolis force is a form of gyroscopic precession. Appendix I provides mathematical explanations and detailed information on how the meter uses this Coriolis force to directly measure mass flow rate.

The amount of twist is directly proportional to the mass flow rate of the fluid flowing through the tubes. Position detectors located on each side of the flow tubes are the primary sensing elements for determining the tube twist angle as a function of time. The detectors send this information to the electronics unit, where it is processed and converted into a voltage proportional to mass flow rate.

In addition to the flow tubes, drive coil, and two position detectors, the sensor unit contains a non-intrusive temperature sensor. A resistance temperature detector (RTD) attached to the sensor tubes determines the temperature.

Figure 4
Flow Tube Assembly

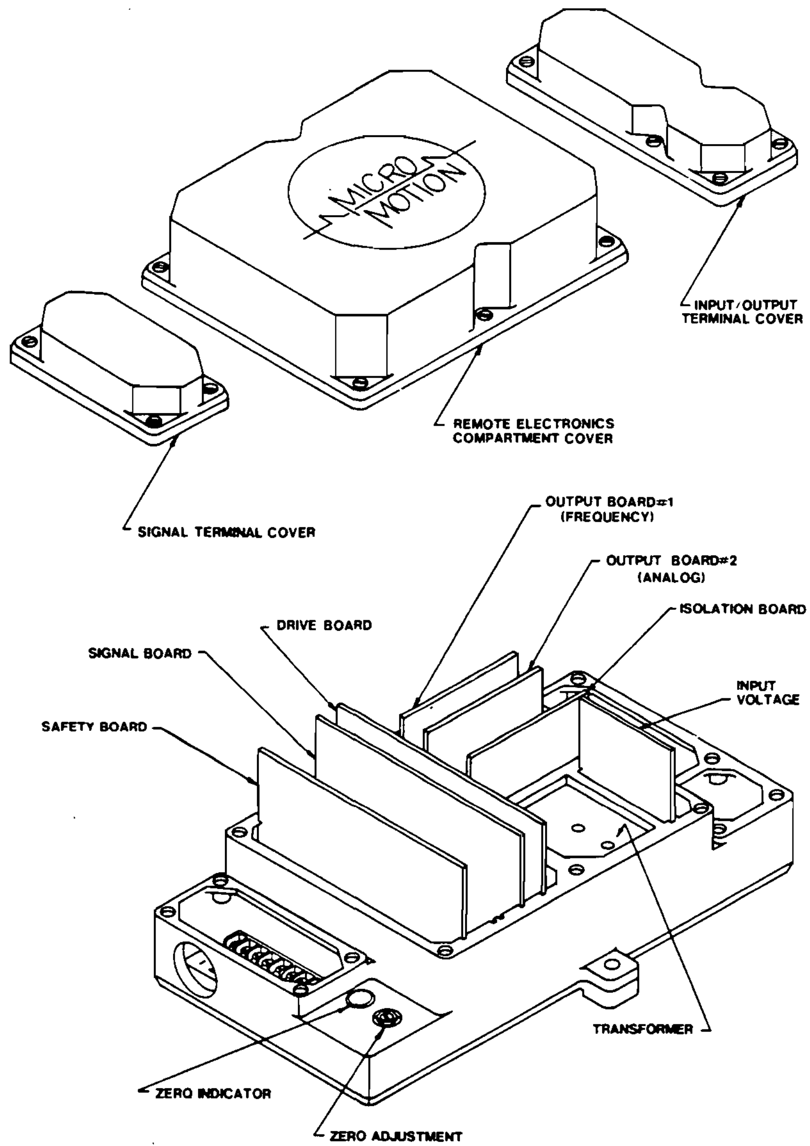


2.4 Electronics Unit

Figure 5 shows the remote electronics unit and identifies the circuit boards within it. Figure 6 shows the electronic circuitry flow diagram from the sensor unit and through the electronics unit. The electronics unit is fuse protected on the input voltage board against power surges from the 100, 115, or 220 VAC power supply and against shorts in the electronics unit. The AC supply voltage is then routed through an encapsulated transformer which reduces it to approximately 25 VAC in preparation for conversion to DC voltages.

When the power supply is 12-30 VDC, the input voltage board converts the DC voltage to an AC voltage. This voltage is then routed through the transformer prior to conversion back to the DC voltages. Fuses are provided on both the DC and AC portions.

Figure 5
Remote Electronics Compartment



On the drive board, the 25 VAC from the transformer is directed through a diode bridge, rectified, and regulated to +15 VDC and —15 VDC. Precision voltage regulator and resistor networks provide the precision +10 VDC and —10 VDC used as reference voltages.

The safety board provides a safety barrier between the electronics and the sensor units. The intrinsically safe board consists of a network of zener diodes and resistors, which limit both the voltage and current of the signals.

The drive and signal boards detect the signal from the left position detector to regulate the drive amplifier. This controls the amplitude at which the flow tubes vibrate. The output is connected to the drive coil in the sensor unit. The positive feedback loop is converted back to a force via the drive coil to reinforce the flow tubes' natural frequency of vibration.

Incoming flow signals from the left and right position detectors are generated by the motion of the sensor tubes. The signal board determines the angle of twist by time integrating the two position detector signals to produce the flow signal. It does this by comparing the left signal to a —VDC reference and the right signal to a +VDC reference. The action of the multiplexer/demultiplexer determines the time integration of the two signals. The phasing is determined by the left position detector. The resultant flow signal is sampled, filtered, and amplified before being routed to the drive board.

The flow rate signal is routed to the voltage-to-frequency converter on the drive board. The drive board uses the signal from the temperature sensor to control the scaling of this conversion. It compensates for the temperature effects on the flow tubes' modulus of rigidity (sheer modulus). The flow direction determines the polarity of the flow signal. The zero indicator light receives a direct pulse output from the drive board. The light responds directly to the primary zero adjustment.

The flow direction signal and the compensated flow rate signal are sent to the isolation board. The isolation board contains two optical couplers which receive the flow rate and direction signals. The couplers reproduce the two pulse inputs as corresponding pulse outputs for further processing. The couplers effectively isolate the output signals from the rest of the meter electronics. This prevents current flow from the safe area into the hazardous area. The breakdown voltage rating is 1300 volts. Additionally, each coupler is protected from reverse surges by a zener diode and a fuse.

The output to the frequency and/or analog output boards is a 0-10,000 Hz signal, proportional to mass flow rate. The frequency board scales the signal to interface with external equipment. The analog board converts the frequency signal to an analog signal prior to sending it to external equipment.

Schematic and assembly drawings for the various circuit boards are shown in Appendix III.

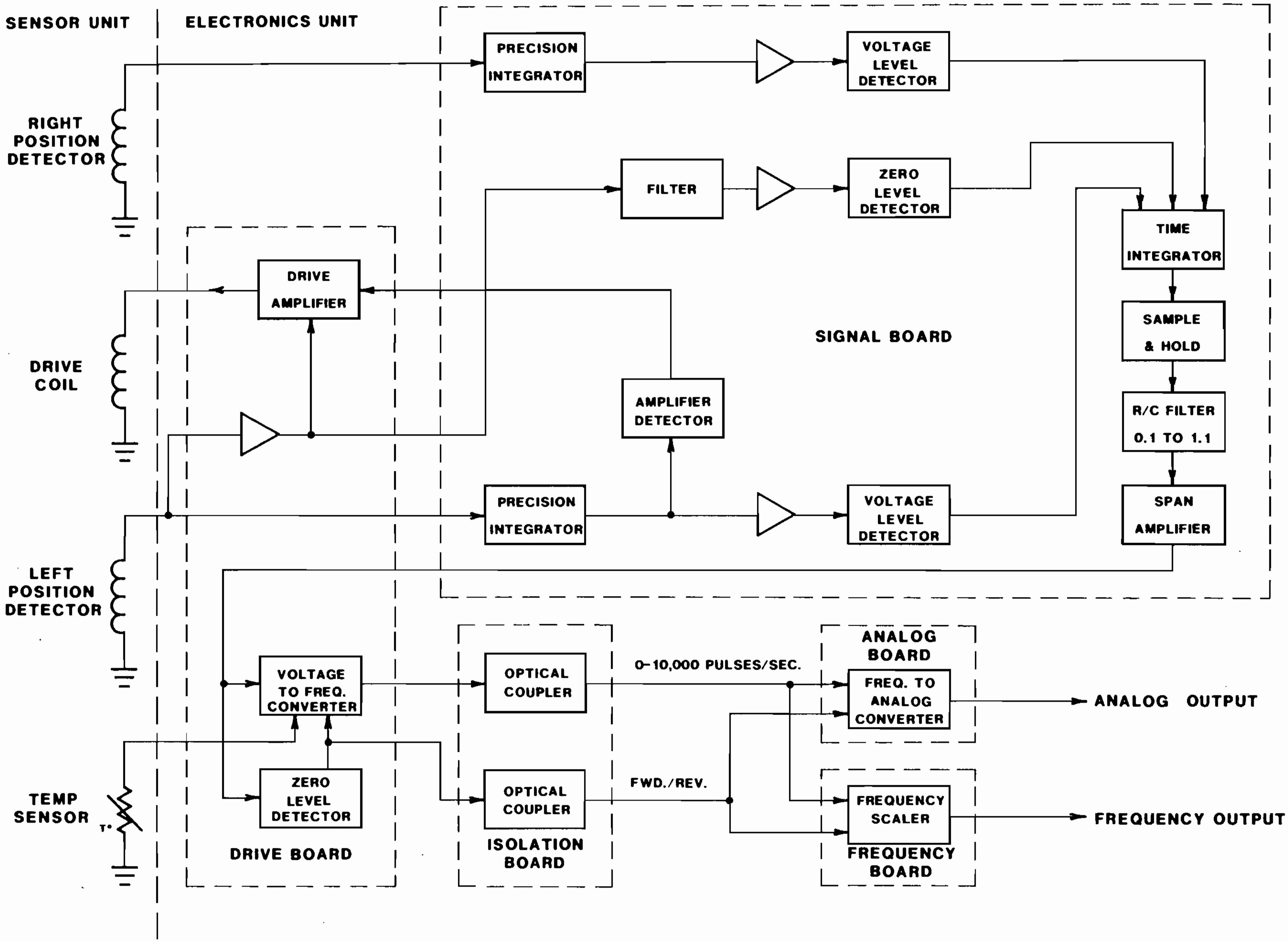


Figure 6
Electronic Circuitry
Flow Diagram

Figure 7
Installation/Flow Direction
Drawing for D25 and Larger
Meters

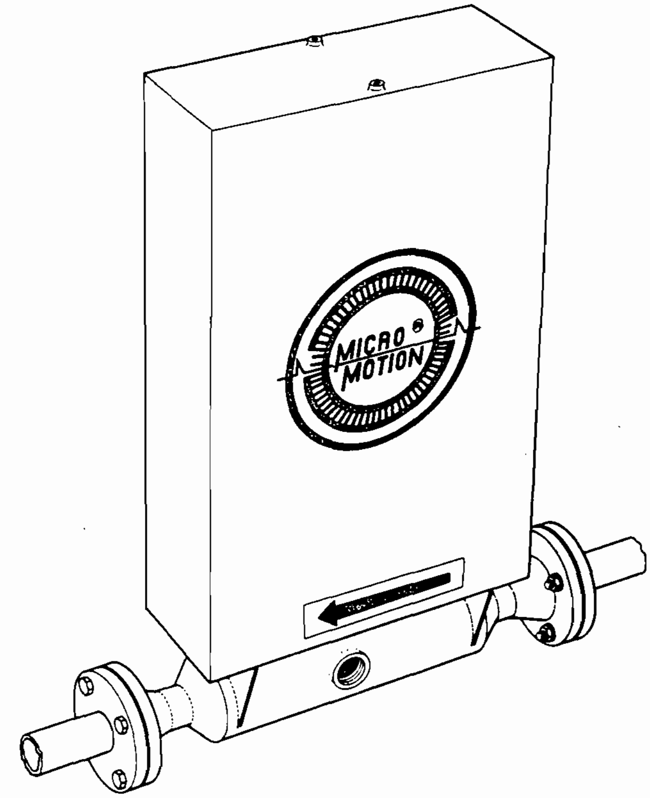
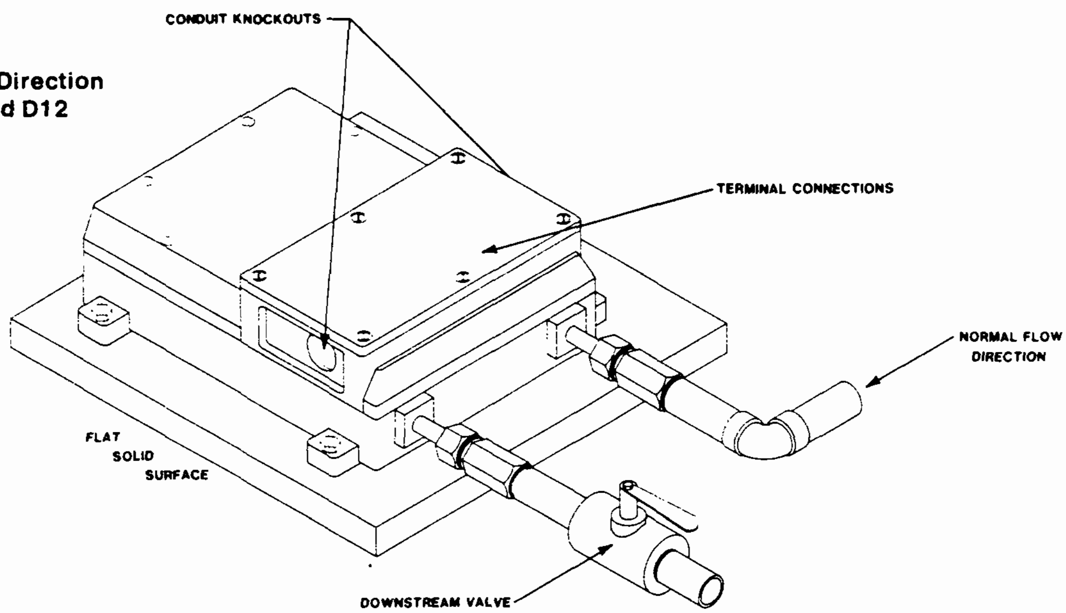


Figure 8
Installation/Flow Direction
Drawing for D6 and D12
Meters



3 Installation

3.1 General

The Micro Motion mass flow meter provides a consistently reliable output with a minimum of maintenance or attention. For optimum performance, read this section carefully before attempting to install the flow meter. Carefully uncrate and inspect all components for visible signs of damage. Immediately report any apparent shipping damage to your factory representative and to the carrier.

Note: The factory calibrates the electronics for the individual sensor unit. Match the electronics to the correct sensor unit. The serial numbers will be the same.

3.2 Location

Locate the sensor unit at least two feet from any large transformer or motor. The mass flow meter employs magnetic fields in its operation, therefore; do not mount the sensor near a large interfering electromagnetic field. Although normal vibrations are not a problem, do not locate in areas susceptible to high vibration (for example, near a motor or pump).

3.3 Orientation

Although sensor orientation does not affect the meter's operation, there are three recommendations:

Install the sensor in a vertical line to avoid particle accumulation in the flow tubes when measuring liquid slurries. This also facilitates cleaning, if process lines are purged with gas or steam.

Install the top of the case downward to avoid trapping air in the tubes when measuring liquid flow.

Install the top of the case upward to prevent accumulation of condensate within the flow tubes when measuring gas flow (Figure 7).

Note: These recommendations apply to the D25 and larger meters. Refer to Section 3.4.1 when installing a D6 or D12.

If possible, orient the remote electronics wiring connections horizontally to avoid possible accumulation of moisture around the conduit connections.

3.3.1 Flow Direction

The meter accurately measures the process fluid regardless of flow direction. For proper output display, however, set the internal electronics accordingly. The mass flow meter is preset at the factory for normal or forward flow direction. The normal flow direction for the D25 and larger meters is marked on the sensor housing as shown in Figure 7. Figure 8 shows the normal flow direction for the D6 and D12.

3.4 Mounting

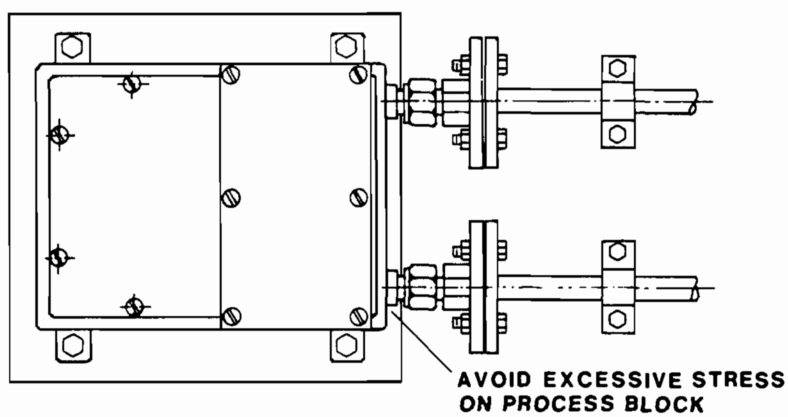
The D25 and larger mass flow meters install directly in-line with the process piping. The D6 and D12 sensor housings require mounting. The remote electronics may be mounted up to 500 feet from the sensor unit. Dimensional drawings for the remote electronics, the various sensors, and the cable junction box are shown in Figure 10, pages 17 through 21.

3.4.1 Mounting the D6 and D12

Mount the D6 and D12 sensor units on a flat, rigid base, such as a concrete wall or floor. Secure all four mounting legs to the same surface. Separate surfaces may move relative to one another due to thermal expansion and contraction. This could cause a zero shift in the meter. The more solid and inflexible the surface, the better the mount.

When the D6 and D12 have flange fittings (either following an adapter or welded on), exercise care not to place excessive stress on the process block. Properly align the process piping with the flanges to avoid excessive stress. Support pipes near the centerline after the flanges. Also, any valves or pumps in the process line near the sensor require their own supports; do not allow the sensor mount or process block to support them. Refer to Figure 9.

Figure 9
D6 and D12 with Flange Fittings



D6, D12 SENSOR WITH FLANGE FITTINGS

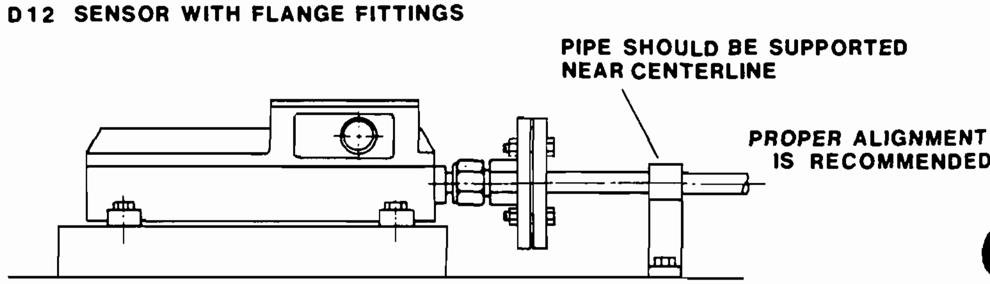
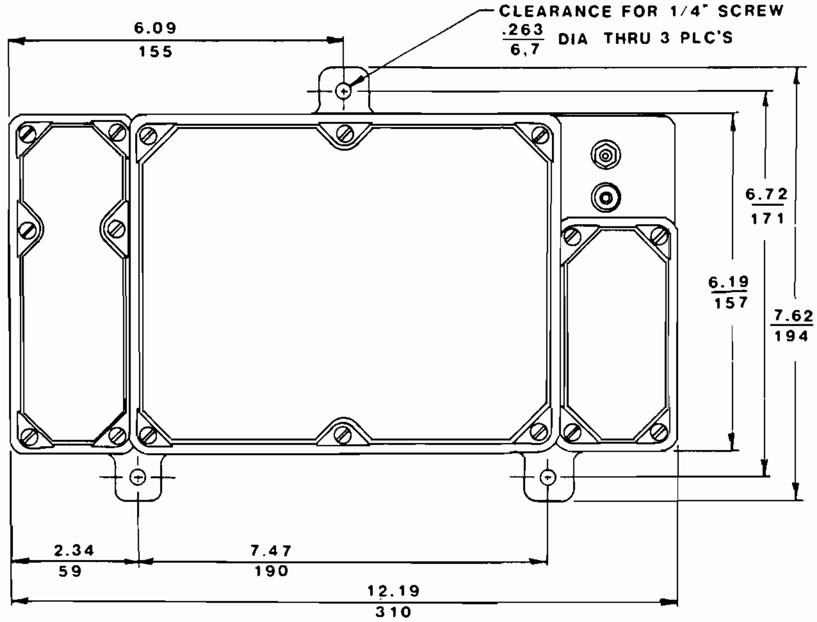
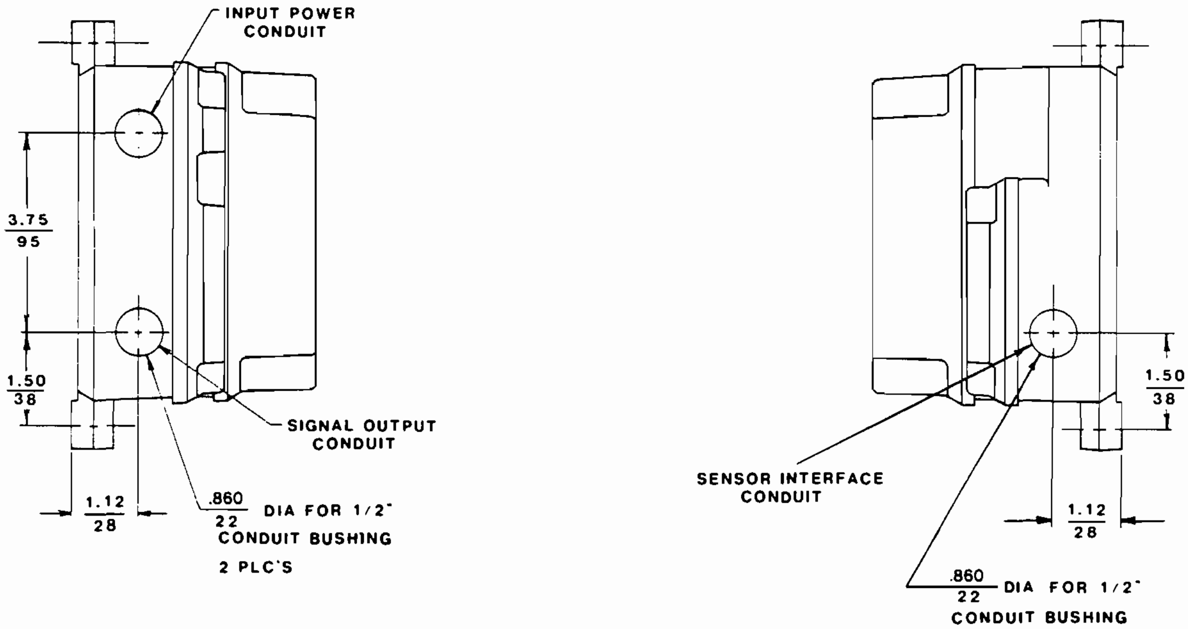


Figure 10a
Dimensional Drawing
Remote Electronics Unit

dimensions $\frac{\text{inches}}{\text{mm}}$



MOUNT SO THAT WIRES ENTER AND EXIT HORIZONTALLY



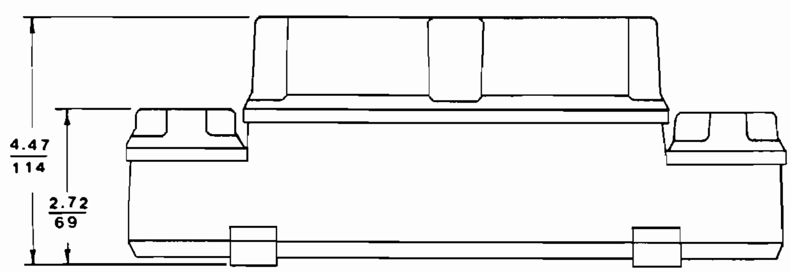


Figure 10b
Dimensional Drawing
D6 and D12

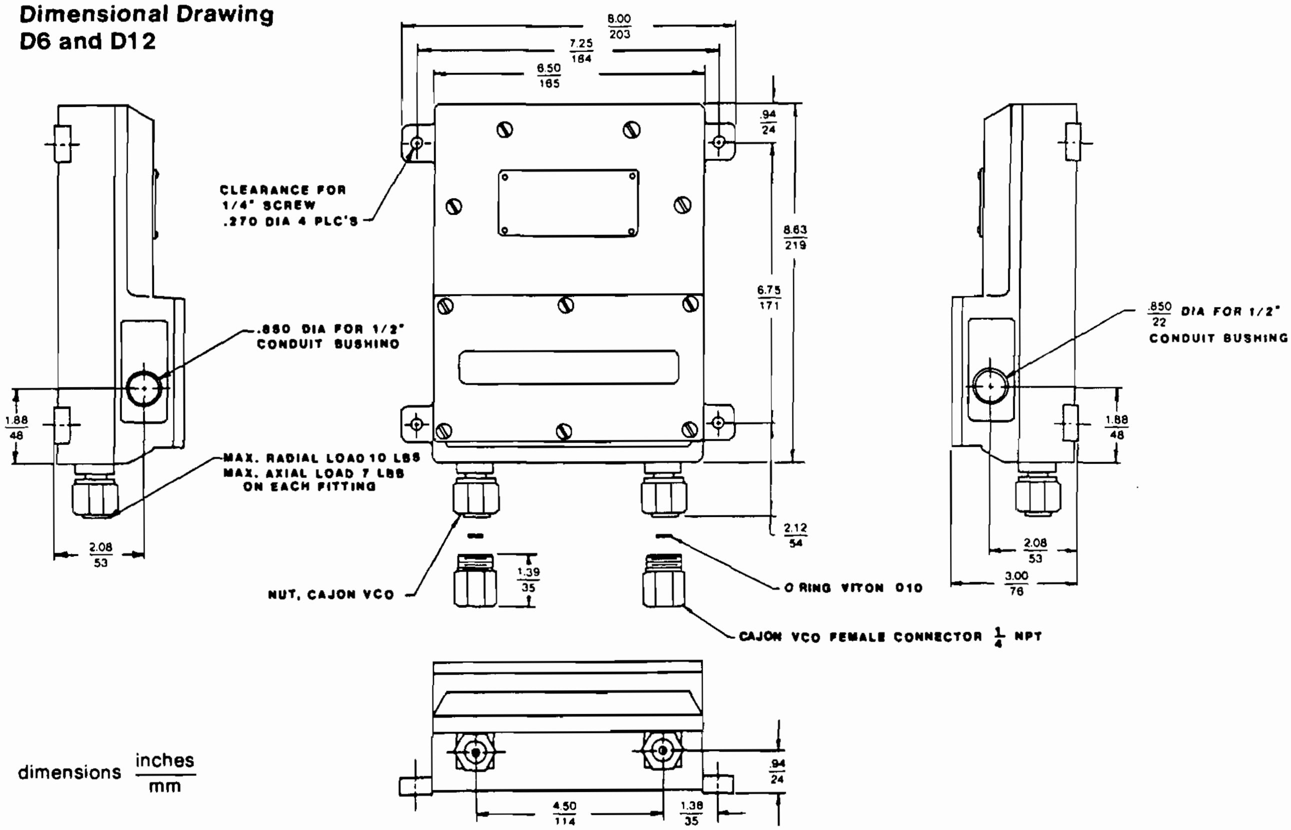
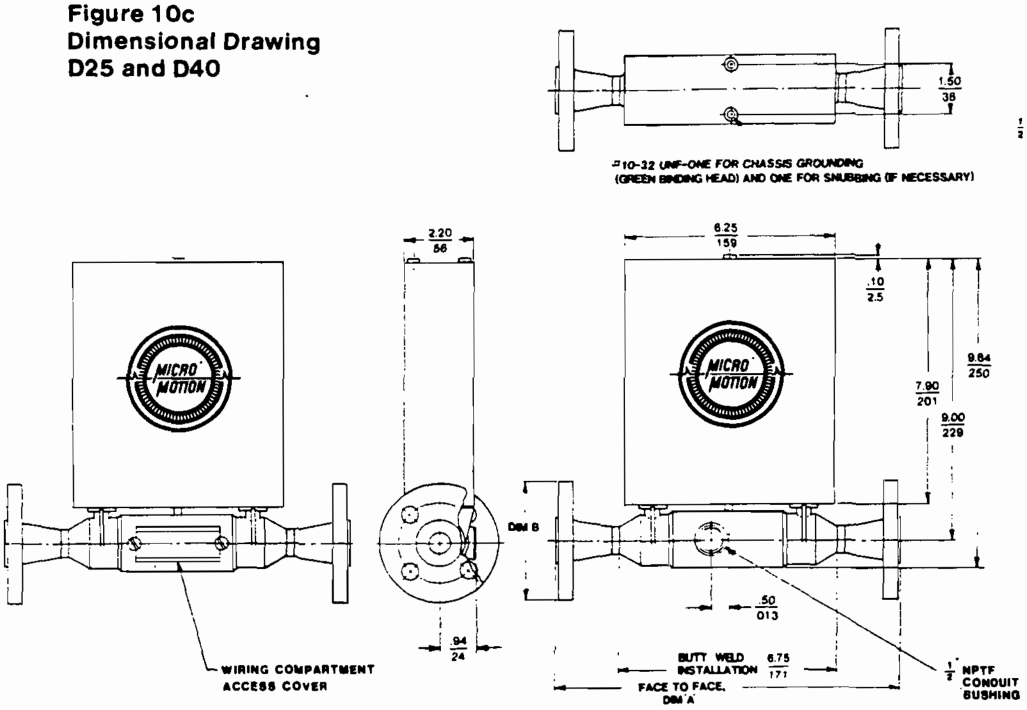


Figure 10c
Dimensional Drawing
D25 and D40



SHOWN

1/2" ANSI RAISED FACE FLANGE 6 (16.5)

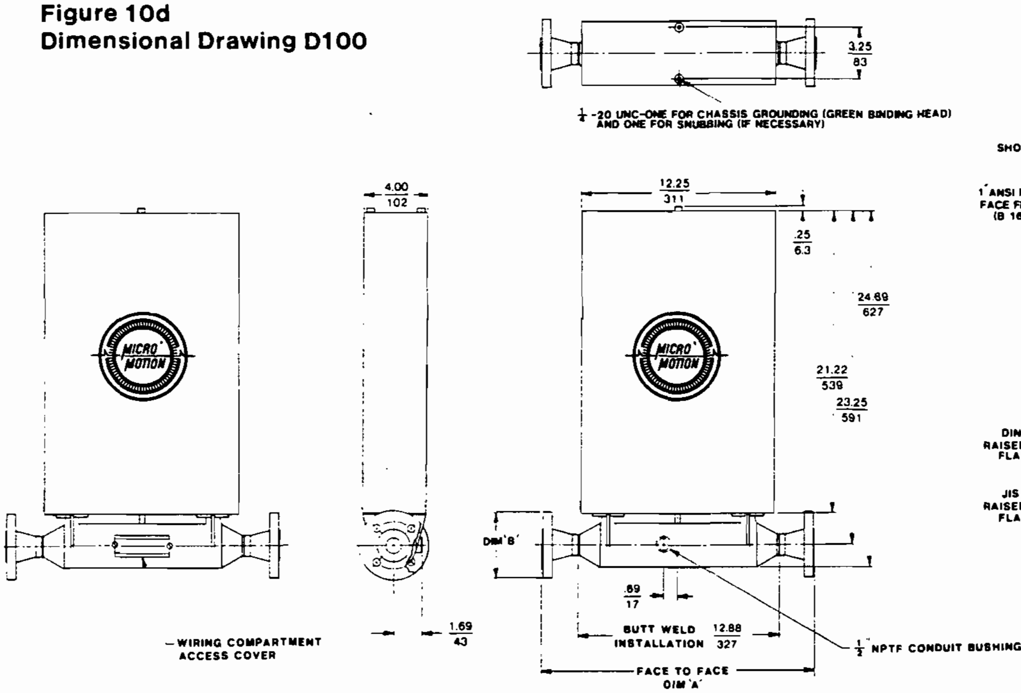
FITTING	DIM 'A'	DIM 'B'
150 LB	10⅛	3½
300 LB	10⅝	3¾
600 LB	11⅛	3¾
½" TUBE LADISH	9⅜	1
½" NPTM	8½	27/32
CAJON	8½	13/16

DIN 15 RAISED FACE FLANGE

JIS 15 RAISED FACE FLANGE

FITTING	DIM 'A'	DIM 'B'
PN40 (2635)	241	95
10Kg (B2212)	235	95
20Kg (B2214)	241	95

Figure 10d
Dimensional Drawing D100



SHOWN

1" ANSI RAISED FACE FLANGE (B 16.5)

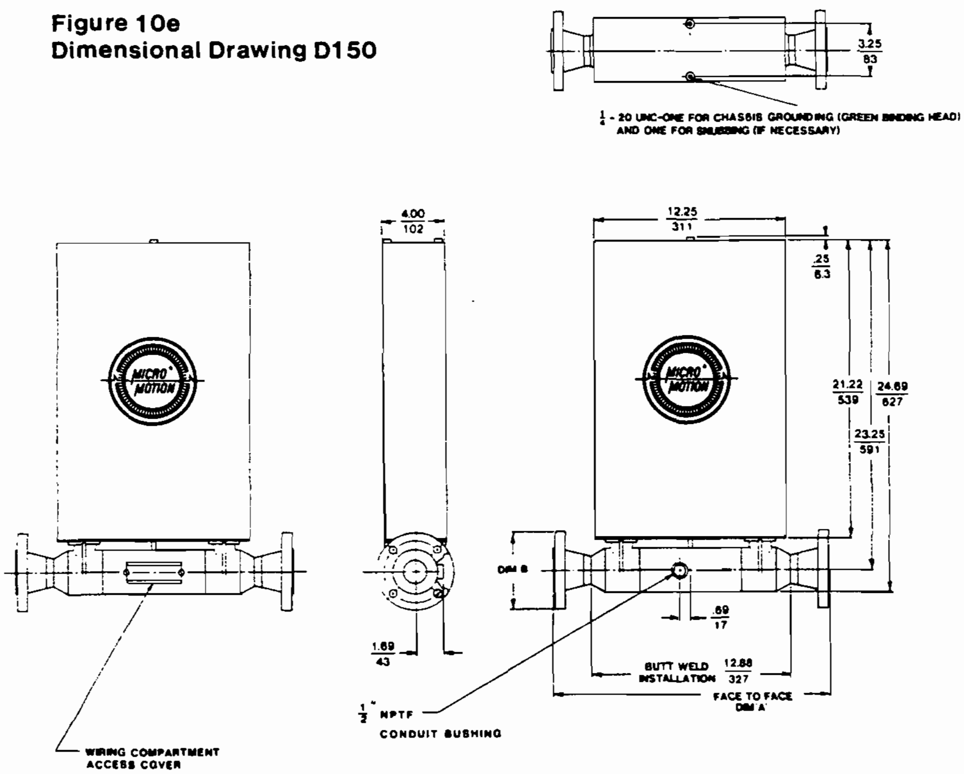
FITTING	DIM 'A'	DIM 'B'
150 LB	17⅛	4¼
300 LB	17⅝	4⅞
600 LB	18⅛	4⅞
1" TUBE LADISH	16	2
1" NPTM	15¼	1 5/16

DIN 25 RAISED FACE FLANGE / JIS 25 RAISED FACE FLANGE

FITTING	DIM 'A'	DIM 'B'
PN40 (2635)	404	115
10Kg (B2212)	400	125
20Kg (B2214)	404	125

dimensions $\frac{\text{inches}}{\text{mm}}$

Figure 10e
Dimensional Drawing D150



SHOWN

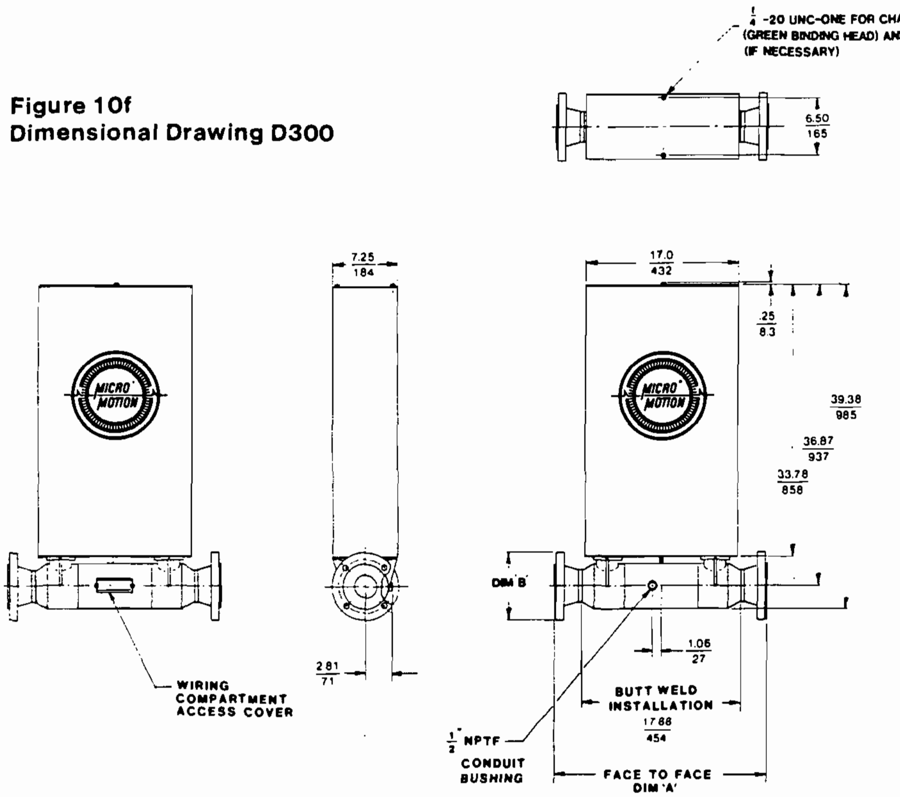
1 1/2" ANSI RAISED FACE FLANGE (B 16.5)

FITTING	DIM 'A'	DIM 'B'
150 LB	17⅝	5
300 LB	18⅛	6⅛
600 LB	18¾	6⅛
1½" TUBE LADISH	16	2
1½" NPTM	15¾	1 29/32

DIN 40 RAISED FACE FLANGE / JIS 40 RAISED FACE FLANGE

FITTING	DIM 'A'	DIM 'B'
PN40 (2635)	414	150
10Kg (B2212)	408	140
20Kg (B2214)	414	140

Figure 10f
Dimensional Drawing D300

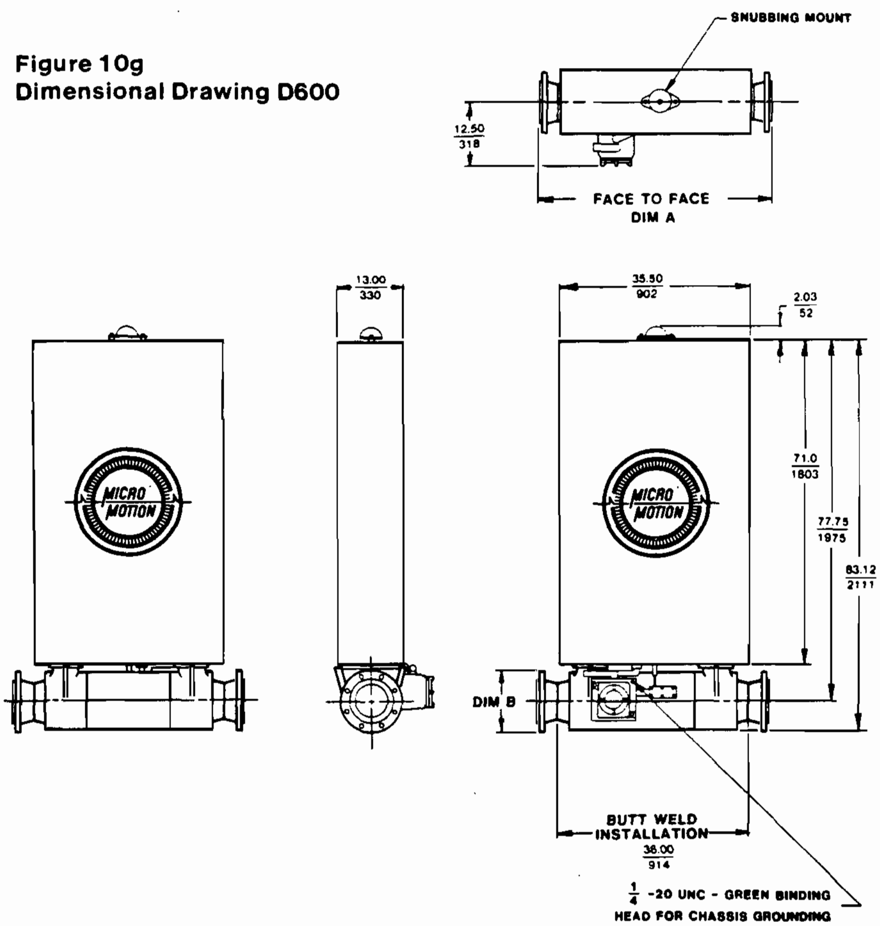


FITTING	DIM 'A'	DIM 'B'
3" ANSI RAISED FACE FLANGE (B 16.5) — 150 LB (SHOWN)	23¼	7½
3" ANSI RAISED FACE FLANGE (B 16.5) — 300 LB	24	8¼
3" ANSI RAISED FACE FLANGE (B 16.5) — 600 LB	24¾	8¼
3" TUBE LADISH	21¾	3 37/64
3" NPTM	22	3½

FITTING	DIM 'A'	DIM 'B'
DIN 80 RAISED FACE FLANGE — PN40 (2635)	567	200
JIS 80 RAISED FACE FLANGE — 10Kg (B2212)	551	185
JIS 80 RAISED FACE FLANGE — 20Kg (B2214)	567	200

dimensions $\frac{\text{inches}}{\text{mm}}$

Figure 10g
Dimensional Drawing D600

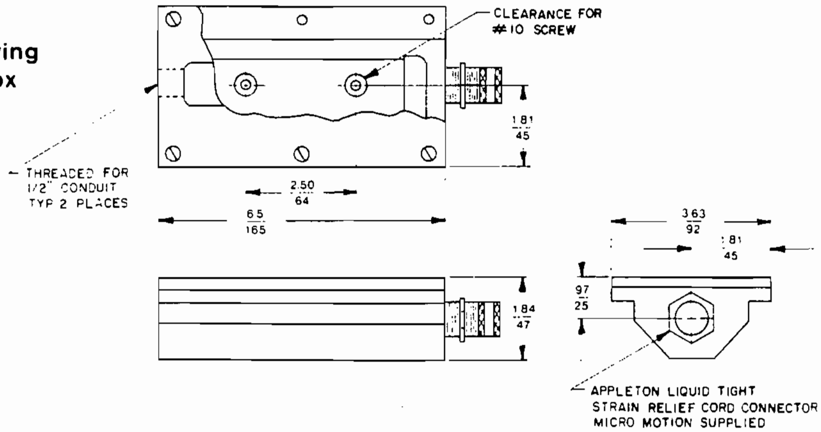


FITTING	DIM 'A'	DIM 'B'
6" ANSI RAISED FACE FLANGE (B 16.5) — 150 LB SHOWN	43	11
6" ANSI RAISED FACE FLANGE (B 16.5) — 300 LB	43¾	12½
8" PIPE (IPS) LADISH	38⅞	7 3/16

FITTING	DIM 'A'	DIM 'B'
DIN 150 RAISED FACE FLANGE — PN40 (2635)	1064	300
JIS 150 RAISED FACE FLANGE — 10Kg (B2212)	1024	280
JIS 150 RAISED FACE FLANGE — 20Kg (B2214)	1064	305

Figure 10h
Dimensional Drawing
Cable Junction Box

dimensions $\frac{\text{inches}}{\text{mm}}$



3.5 Piping Connections

3.5.1 Fluid Fittings

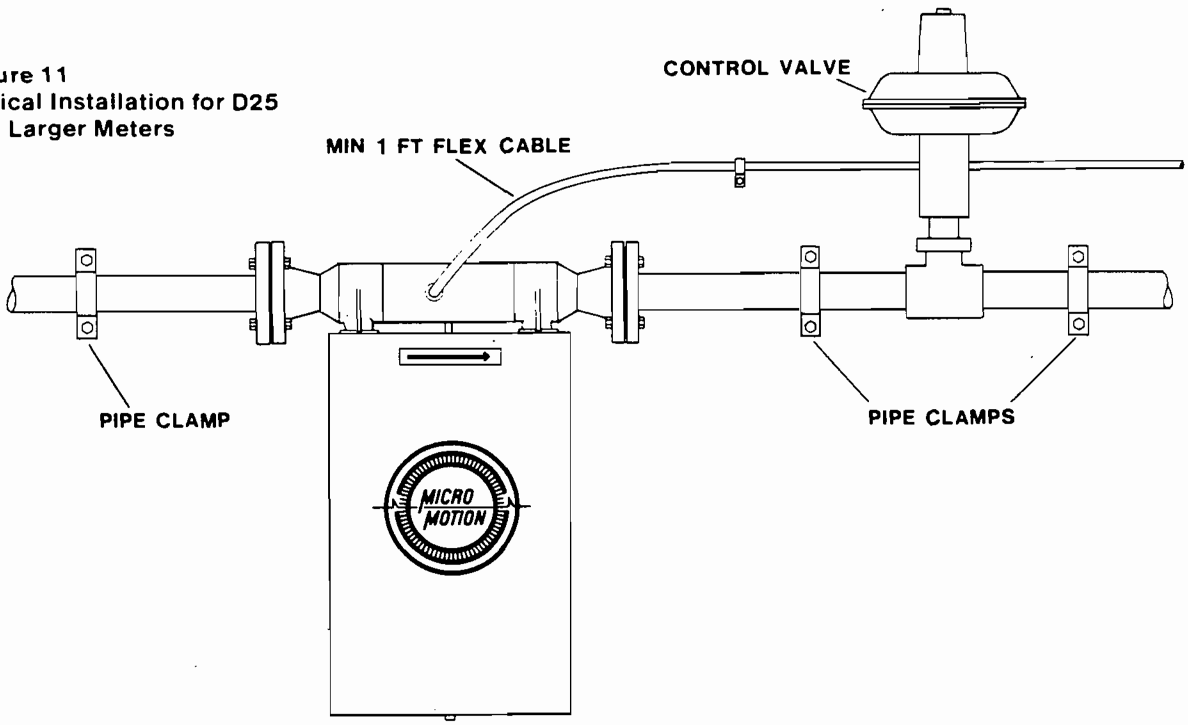
Observe good piping practices during meter installation. For best results, provide pipe supports near the fluid fittings; preferably, vibration isolation type supports should be used (such as those manufactured by Stauff, Behringer, etc.). Do not use the fluid fittings as pipe supports. Install inlet and outlet piping using appropriate anchors, guides, expansion joints, hangers, or other mechanical support systems. Ideally, the process piping should be secured to the same mounting surface as the sensor units on the D6 and D12. On the D25 and larger meters which install directly in-line, place additional pipe supports near the first elbow in the process line or ten to twenty pipe diameters from the fluid fittings. See the typical installation shown in Figure 11.

3.5.2 Downstream Valve

A downstream shutoff valve is recommended to ensure actual zero flow when setting the primary zero adjustment.

In batching operations the flow meter and shutoff valve should be located as close as possible to the receiving tank to minimize errors. Also, flexible piping between the meter and the shutoff valve will cause batching errors, since flex tubing expands and contracts in response to system pressure.

Figure 11
Typical Installation for D25 and Larger Meters



3.6 Wiring Connections

Danger: Power must be OFF when making wiring connections.

Wiring connections for the remote electronics are located at both ends of the unit. Remove the terminal covers to expose the connections.

Appropriate conduit connectors are provided to seal the remote electronics against moisture, dust, etc. Figure 12 shows the proper installation of these connectors.

Wiring connections for the D6 and D12 are located on top of the sensor unit. Remove the terminal cover to gain access to the terminal connections. Determine in which side of the sensor unit the cable will enter. Then, remove the knockout to provide an opening for the cable.

Wiring connections to the D25 through D300 meters are made at the manifold spacer. Loosen the slotted head screws on the wiring compartment cover to gain access to the sensor wires.

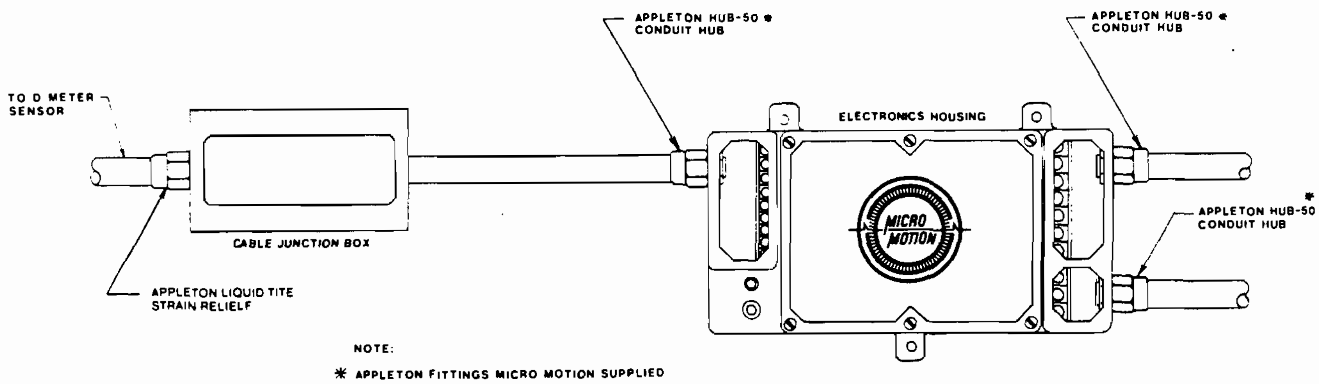
Wiring connections to the D600 are made at the booster amplifier (explosion-proof box on manifold) and the cable junction box (on the manifold). Remove the explosion-proof housing cover and the cable junction box cover to gain access to the terminal strips.

3.6.1 Power Connections

The factory installs the appropriate input voltage board for the customer's application. This allows the meter to accept one of the following input voltages: 115, 220, 100 VAC, or 12-30 VDC. The input voltage board can be changed in the field to accommodate different power supplies. Simply replace the input voltage board with the desired input voltage board. Input power connections are made on terminals 10 and 11 of the remote electronics compartment. When the meter is used with a DC power supply, terminal 10 is positive and terminal 11 is negative. Terminal 12 is earth ground in all cases.

Caution: Power supply voltage must agree with the voltage stated on the input voltage board.

Figure 12
Conduit Connectors



The DC powered meter has two primary uses. First, a battery can be used in remote or mobile applications where AC power is inaccessible. Second, a DC power supply can be used in conjunction with a battery backup for critical processes.

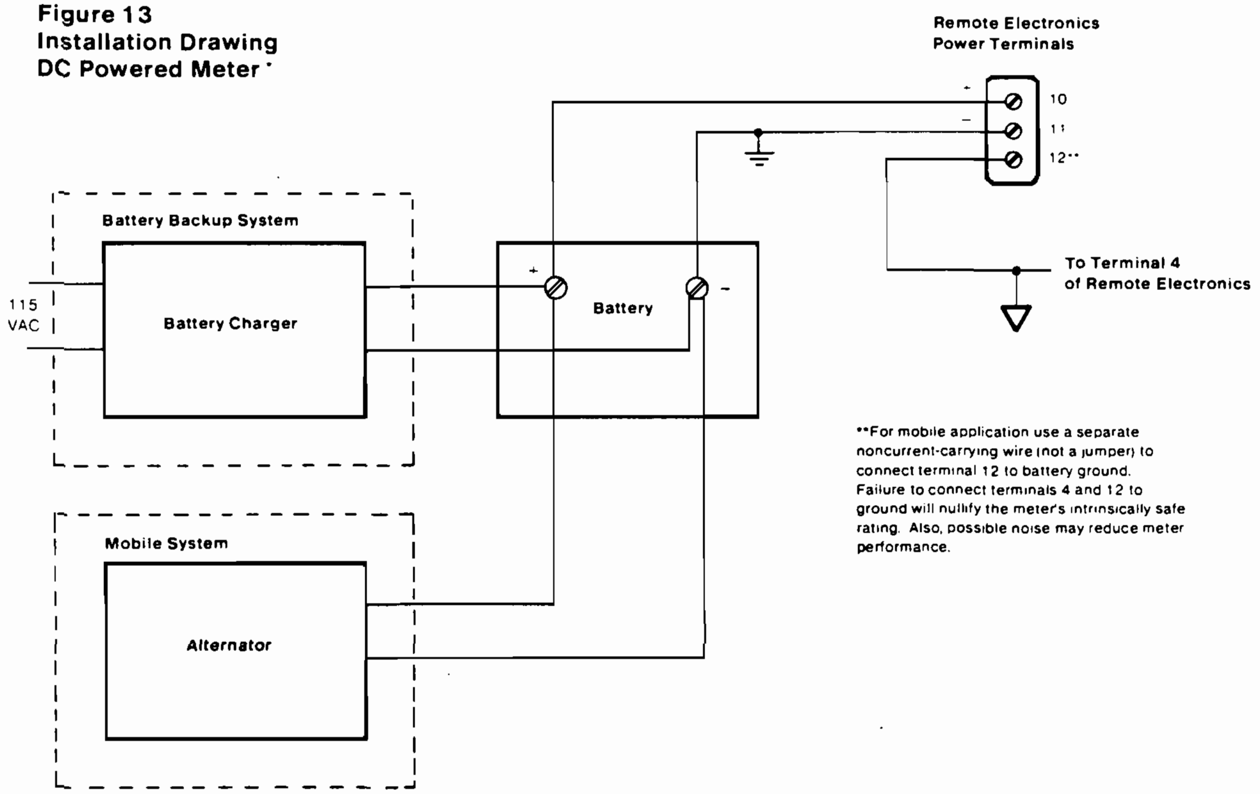
Note: Momentary power surges cause only brief fluctuations in the meter output without affecting accuracy or damaging the meter's electronic components. Longer brownouts or blackouts will affect the meter's output accuracy, since the meter must stabilize when restarted.

Figure 13 shows a wiring diagram for a DC powered meter.

The D600 has a booster amplifier which requires a 115 or 220 VAC power supply. The power must match the power indicated on the voltage label inside the explosion-proof housing. Figure 15c shows the booster amplifier wiring connections.

Caution: Replace and tighten covers before turning on power.

Figure 13
Installation Drawing
DC Powered Meter *



**For mobile application use a separate noncurrent-carrying wire (not a jumper) to connect terminal 12 to battery ground. Failure to connect terminals 4 and 12 to ground will nullify the meter's intrinsically safe rating. Also, possible noise may reduce meter performance.

*The mass flow meter electronics unit must be equipped with a 12-30 VDC input voltage board.

3.6.2 Signal Wiring

3.6.2.1 Conduit Connections. The conduit fitting in the D25 through D300 sensor units is a 1/2 inch NPTF size bushing. Connect a 1/2 inch NPT male conduit cord grip or flexible conduit to it. The cord grip must be compatible with the environment. For example, if the meter is operating at 200°C, the conduit cord grip must be capable of withstanding 200°C. Or, if the environment is corrosive, it must be corrosion-resistant.

Note: When using conduit, at least the first foot attached to the bushing should be flexible. This prevents the conduit from coupling unwanted vibrations to the sensor.

Flexible conduit is UL approved. According to NEC standards, explosion-proof conduit is not required for intrinsic safety. The connection must, however, be sealed.

The conduit fittings to the D600 booster amplifier and junction box are 1/2 inch NPTF size bushings. Explosion-proof conduit must be connected to the booster amplifier (Figure 15c). Also, it must be sealed.

3.6.2.2 Cable Connections. Signal connections are made via the interconnect cable between the sensor unit and terminals 1-9 of the remote electronics unit. At least one end of the cable must be prepared in the field. Micro Motion includes a package which contains the necessary butt splices, spade lugs, shrink-tubing, solder sleeve, connection wire and instructions with each meter. Figure 14 shows the function of each connection. Individual wires are colored for easy identification. Refer to Figures 15a and 15b to connect cable to the remote electronics unit.

If the interconnect cable exceeds 10 feet and a junction box is used, Figure 15a also shows how to connect the signal wiring from the sensor and the electronics to the junction box. A junction box is attached to the D600 sensor unit and wiring connections are made from the junction box to the remote electronics unit as shown in Figure 15a. Connections from the junction box to the D600 sensor unit are not shown, because the factory completes these connections.

Wiring connections to the D6 and D12 are made at the top of the sensor unit. The sensor unit terminal strip is shown in Figure 16.

Wiring connections to the D25 through D300 sensors are made at the manifold spacer. Loosen the slotted head screws on the wiring compartment cover (Figure 15) to gain access to the sensor wires. Butt splices are attached to the wires inside the manifold spacer. Route this end of the cable through the conduit opening. Then, insert the prepared wire ends into the butt splices, being sure to match wire color to wire color. For easy identification, a single 20 gauge yellow wire is supplied to join the ground shields. Crimp the interconnect cable to the butt splice using a standard type crimping tool (such as Stakon, Amp, etc.).

Note: The wires must be paired exactly as shown in Figure 15 (for example, wires connected to the electronics unit terminals 3 and 9 must be paired together; wires connected to terminals 1 and 2 must be paired, etc). If the cable is not supplied by Micro Motion, make certain each pair is individually shielded. All ground shields should be connected to terminal 6 and insulated to avoid accidental grounding to the case.

3.6.2.3 Intrinsically Safe Wiring Requirements. To maintain their UL rating, intrinsically safe meters must be installed in accordance with Figure 16a. For BVS approvals, meters are also installed in accordance with Figure 16a. Wiring connections for CSA approved intrinsically safe meters must be made in accordance with Figure 16b.

Note: Failure to connect terminals 4 and 12 to earth ground will nullify the intrinsically safe rating. Also, meter performance may be reduced because of possible noise.

Figure 14
Terminal Connections

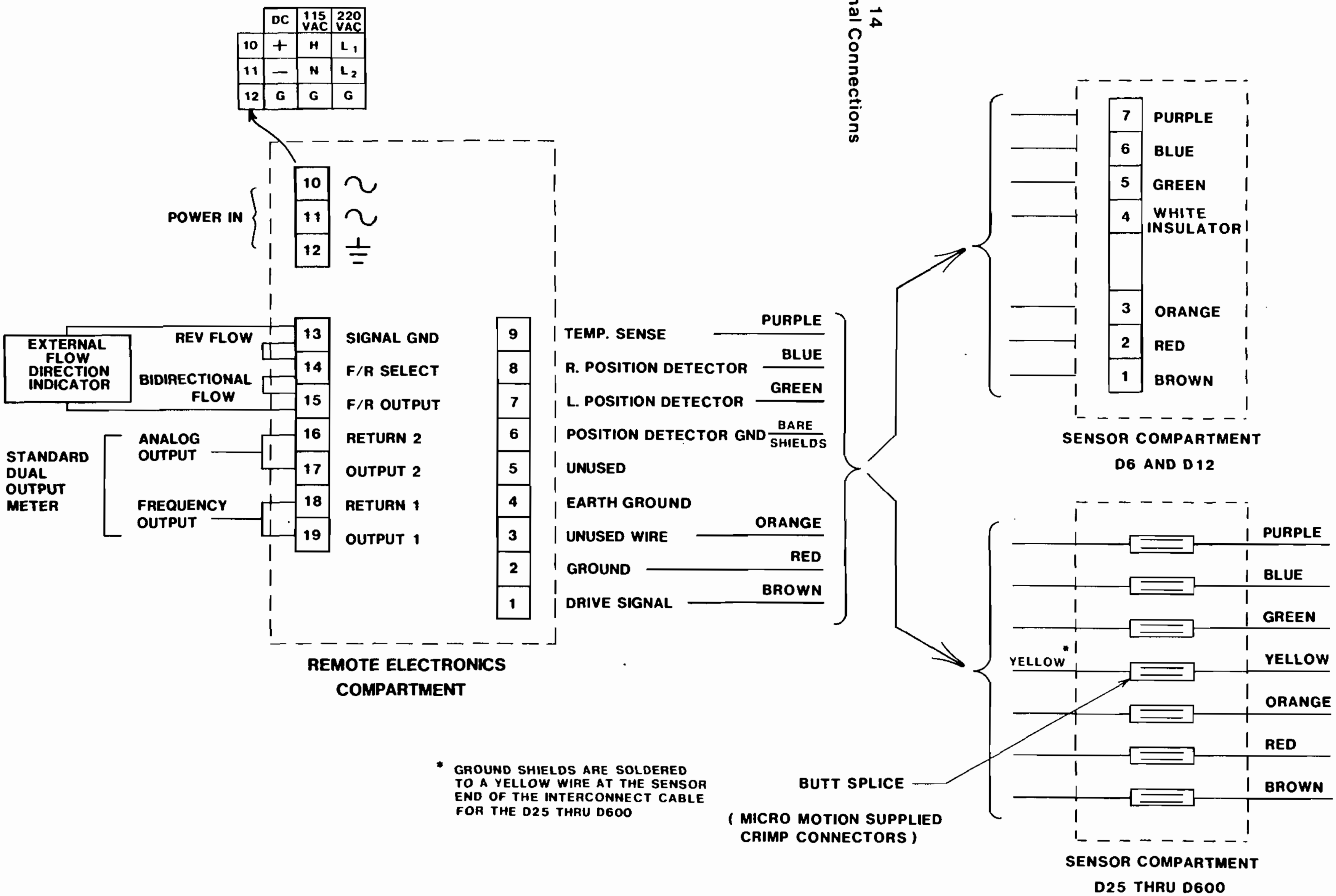


Figure 15a Cable Connections Through Junction Box

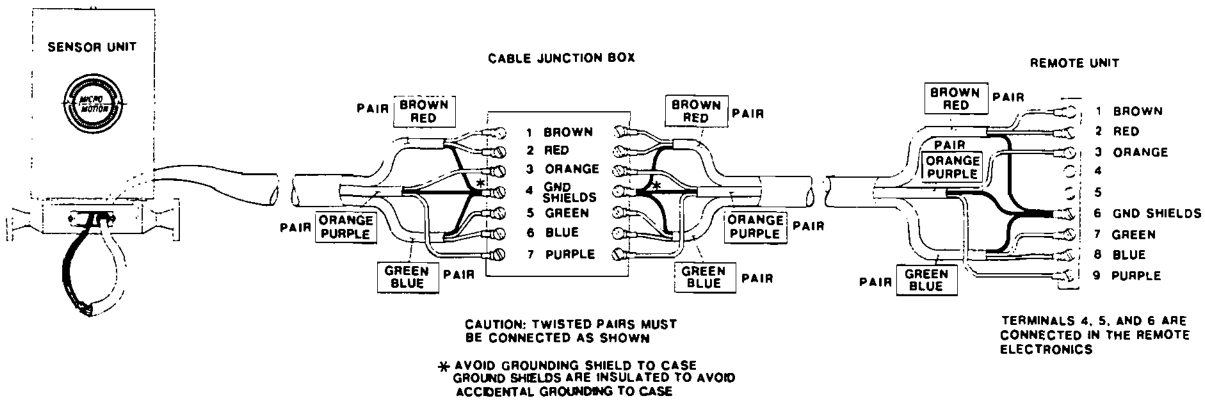
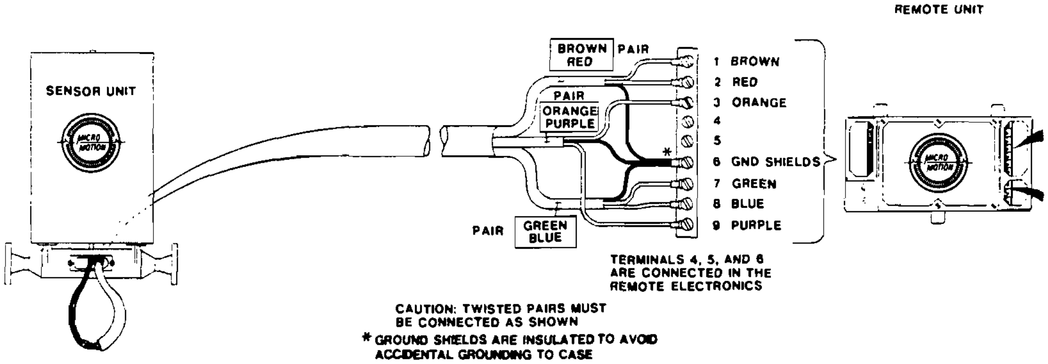


Figure 15b Cable Connections Sensor to Electronics



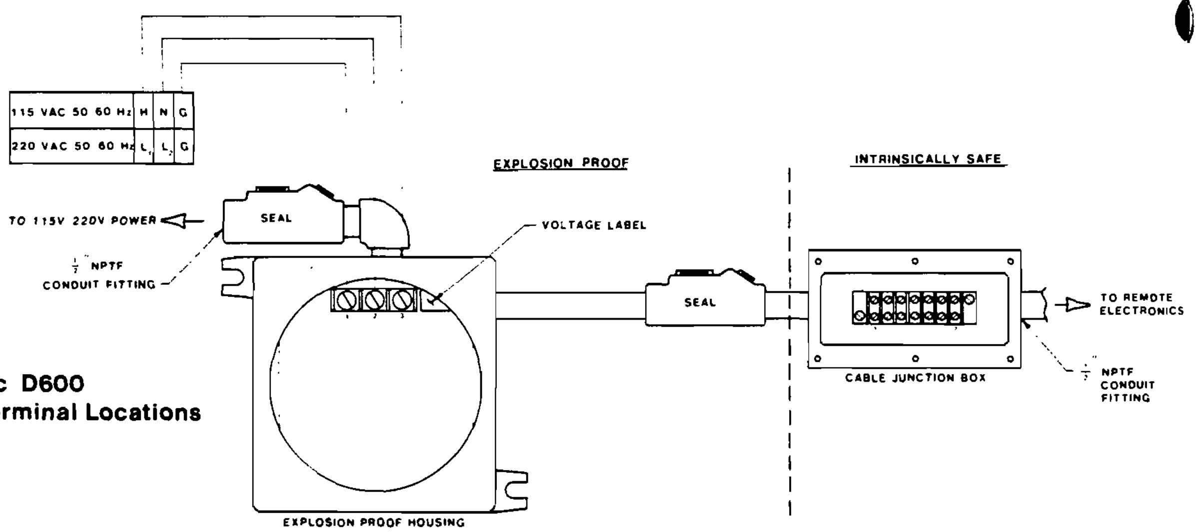


Figure 15c D600
Sensor Terminal Locations

3.6.3 Output Wiring

Wiring to output devices should be shielded from input power wiring to avoid possible electrical interference. Select a wire gauge which maintains less than 10 ohms resistance per output loop. For example, 20 gauge wire may be used up to 500 feet away. Larger gauge wire is required for longer runs.

3.6.3.1 Flow Direction Wiring. The mass flow meter is preset to measure forward flow. Terminals 13, 14, and 15 furnish the connections for flow direction display and selection. When the meter is installed for forward flow and no external flow direction display is desired, no connections to terminals 13, 14, and 15 are required. If reverse flow is desired, a jumper must be installed between terminals 13 and 14. For bidirectional flow, install a jumper between terminals 14 and 15. In this case, a high (15 VDC) output indicates forward flow direction, and a low (GND) output indicates reverse flow. Connect the external flow direction indicator between terminals 13 (signal ground) and 15 (forward/reverse output) of the flow meter electronics.

Figure 16a UL and BVS Intrinsically Safe Installation Drawing

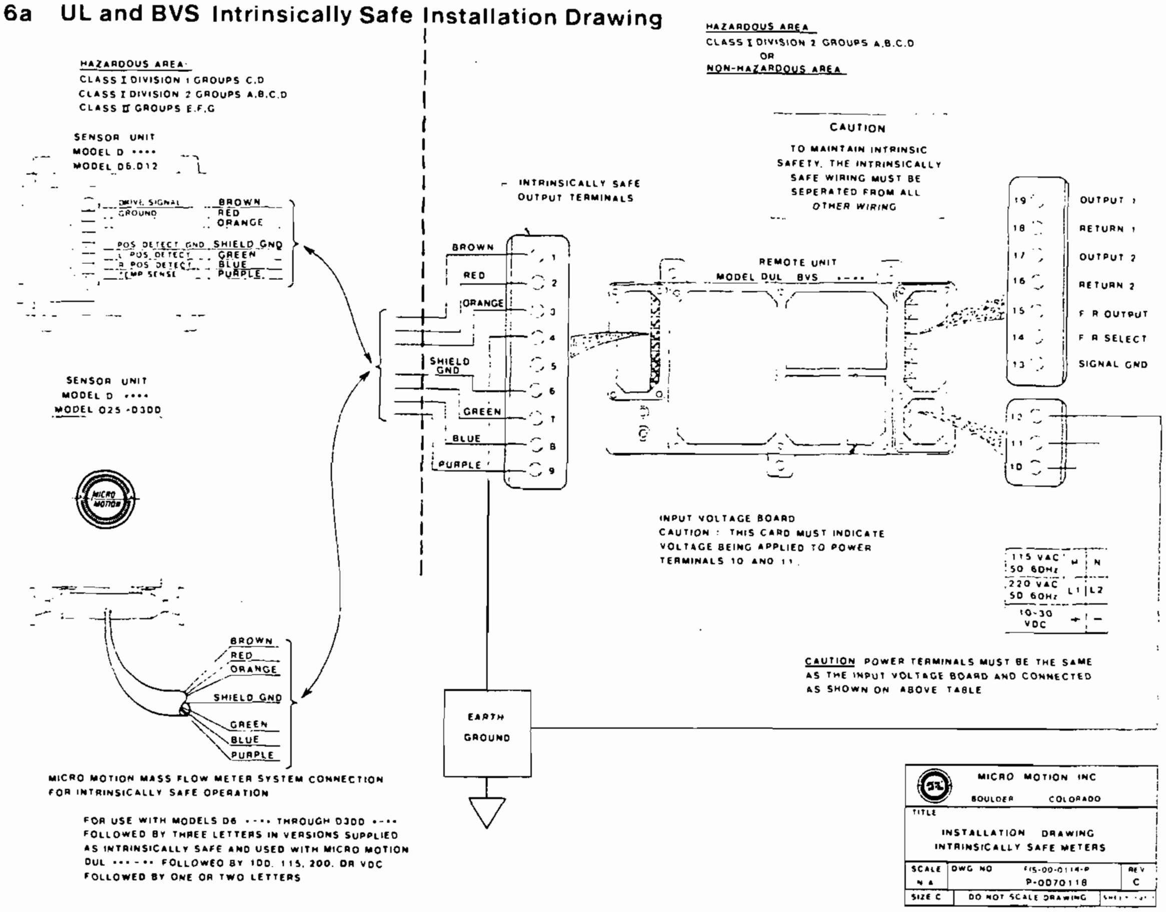
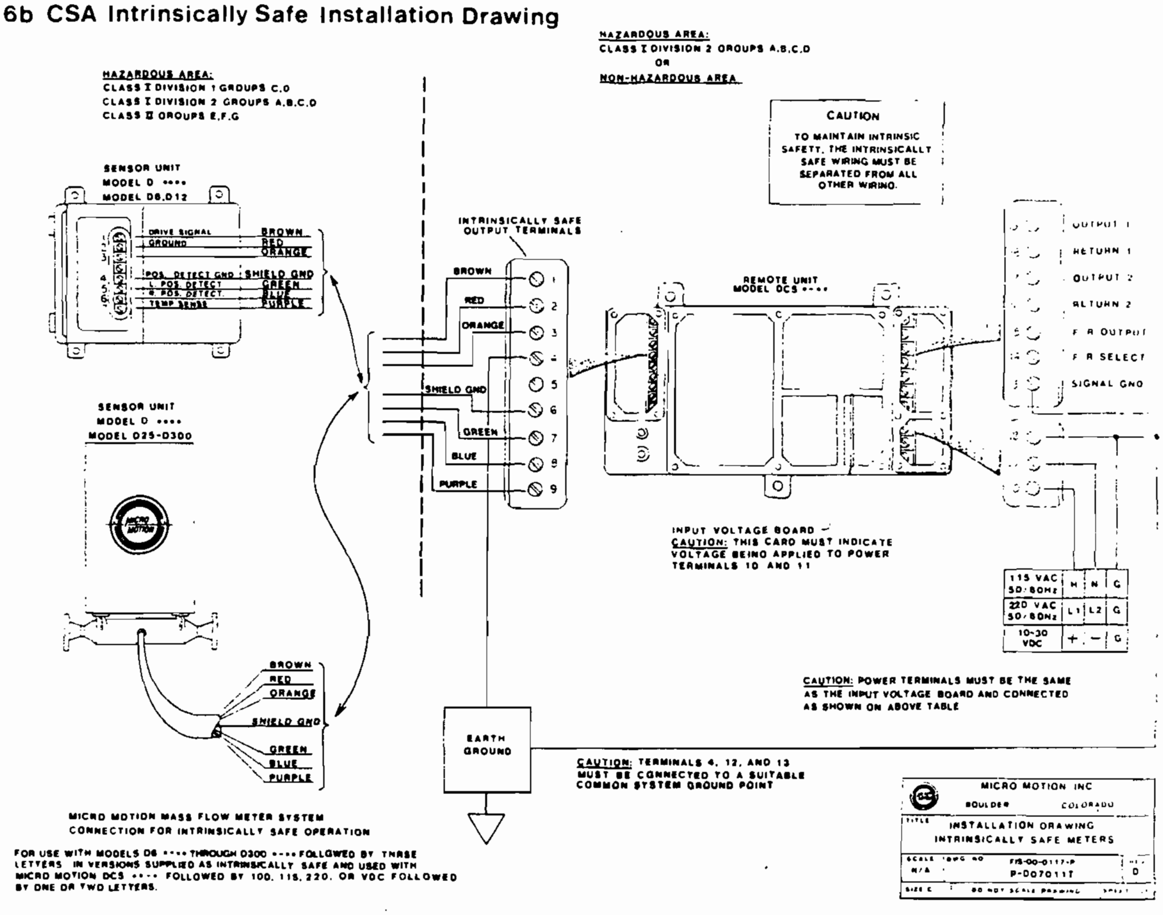


Figure 16b CSA Intrinsically Safe Installation Drawing



3.6.3.2 Analog Output Wiring. When connecting an analog device to the Micro Motion Mass Flow Meter, terminals 16 and 17 of the flow meter are usually the analog output (in a standard analog-frequency meter). Figure 32 in Appendix II shows typical output wiring to an analog device. Terminal 17 is the signal line and terminal 16 is the return. The signal is active and can actually power some output devices, such as Micro Motion's model PI 4-20 Process Indicator.

3.6.3.3 Frequency Output Wiring. The output circuit is rated to 30 VDC, 1 amp signal. The frequency board uses an N-channel MOSFET output driver. The output from the frequency board is nominally 15 V logic level square wave (as seen on an oscilloscope). It can interface with TTL, DTL, CMOS, and most computer signals. Appendix II contains detailed information on the frequency output.

To connect the mass flow meter to a frequency device, the terminals usually used are 18 and 19. Figures 33a through 33h in Appendix II show the standard frequency output and typical wiring diagrams. In a standard analog-frequency meter, terminal 19 is the signal line and terminal 18 is the return.

3.6.3.4 Fully Isolated Outputs. In standard analog-frequency meters, both outputs are referenced to a floating signal ground. On CSA installations signal ground must be connected to earth ground. For applications requiring fully isolated outputs, the frequency boards may be equipped with an optional modification. The modification uses an optical coupler on the frequency output. Figure 33h in Appendix II shows the isolated output connected to a counter.

Note: With this option, the circuit contains a solid state relay rated to 250 Volts at 150mA. The frequency is limited to 500 Hz maximum.

3.7 Special Applications

3.7.1 Corrosion Resistant Meters

Lined or coated meters operate in applications where the 316L stainless steel sensor tubes are not compatible with the process fluid. In these cases the sensor tubes are lined with Teflon TFE® or coated with Halar ECTFE®.

The lined and coated meters have lower pressure and temperature ratings. The operating temperature of the meter should not exceed 300°F if the meter is lined with Teflon®, or 250°F if the meter is coated with Halar®. The maximum operating pressure of the lined and coated meters is 1000 psi (pounds per square inch) or the rated operated pressure of stainless steel tube meters of the same size, whichever is lower.

3.7.1.1 Precautions. The meters are shipped with protective flange covers to prevent damage and distortion of the liner flare. Remove the covers for inspection purposes and then replace the covers until the meter is to be connected to the piping.

3.7.1.2 Thermal Isolation. The flanges and the sealing flare should be thermally isolated from any process (such as welding, brazing or soldering) which employs temperatures above 300°F, since such temperatures can deform or distort the liner and flare material.

3.7.1.3 Gaskets, Bolts. Mating the meter with flanges of a dissimilar material such as Hastelloy®, stainless steel, glass, reinforced plastic, etc. requires gaskets. The same is true if piping lined with a similar material employs cocked flanges for sloped runs. In these cases use a tapered gasket of a resilient material, or a TFE gasket machined from extruded Teflon® bar stock. If the mating flange covers the raised face and flare of the meter flange, the gasket diameter must not exceed the diameter of the raised face of the meter flange.

®Teflon TFE is a trade name product of the E. I. Dupont Corporation.
®Halar ECTFE is a trade name product of the Allied Corporation, Allied Fibers and Plastics Division.
®Hastelloy is a trade name product of the Cabot Corporation, Cabot Wrought Products Division.

Tighten the flange bolts according to Table 6 and the tightening pattern below. Washers should be inserted under both the bolt head and the nut. To ensure proper torquing, the bolt threads should be inspected and lightly lubricated before installation.

If the meter operates at 50°F above ambient temperature, check the coupling or bolts after the first cool-down period. Also recheck the fitting if a leak occurs during operation at elevated temperatures. If leaks occur during subsequent operation, refer to Section 3.7.1.4, Troubleshooting.

3.7.1.4 Troubleshooting. Troubleshooting procedures for the meter electronics are covered in Section 4.5. If a leak occurs at the fittings, proceed as follows:

If a leak is detected at a flange interface, and the bolts have been properly torqued, do not tighten them further. Over-torquing may cause permanent damage to the sealing flare. Instead, loosen the bolts on the side opposite the leak by 1/4 turn. Then tighten the bolts on the leaking side to the specified torque.

Caution: Flange bolts must not be loosened while the system is at pressures greater than 10 psig or while the temperature is greater than 40°F above ambient. Distortion or collapse of the sealing flare could result.

If the leak persists after several repetitions of the above procedure, separate the flanges and inspect the sealing flare and gasket for damage. Scratches or dents across a sealing surface may provide a path for leaks. Shallow scratches in the sealing flare may be removed by buffing with a fine abrasive paper.

After removing the meter from the piping (or whenever the sealing flange and flare are separated), flange covers or blind flanges should be employed to protect the sealing flare.

3.7.2 Mobile Applications

The snubber on top of the sensor unit may be used to stabilize the sensor unit for mobile applications,such as trucks, trailers, skids, etc. Special wiring requirements for mobile units with DC powered meters are covered in Section 3.6.1.

3.7.3 High Temp. or Cryogenic Applications

The D Meter sensor housing may be insulated to prevent excessive heat loss. For high temperature applications, heat tracing may be applied directly to the stainless steel case, as long as the heat tracing fluid does not exceed 400°F.

Table 6
Gasket and Bolt Tightening

Model	*100*	*150*	*300*	*600*
ANSI 150 lb. flange	1"	1 1/2"	3"	6"
Flange hole size	5/8"	5/8"	3/4"	7/8"
Bolt/thread size	1/2-13	1/2-13	5/8-11	3/4-10
Bolt torque	10 ft/lb	15 ft/lb	25 ft/lb	40 ft/lb

Ladish fittings use O rings. These O rings may the inserted in the normal manner.

Tightening pattern

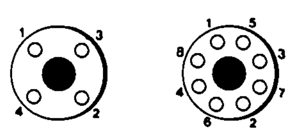
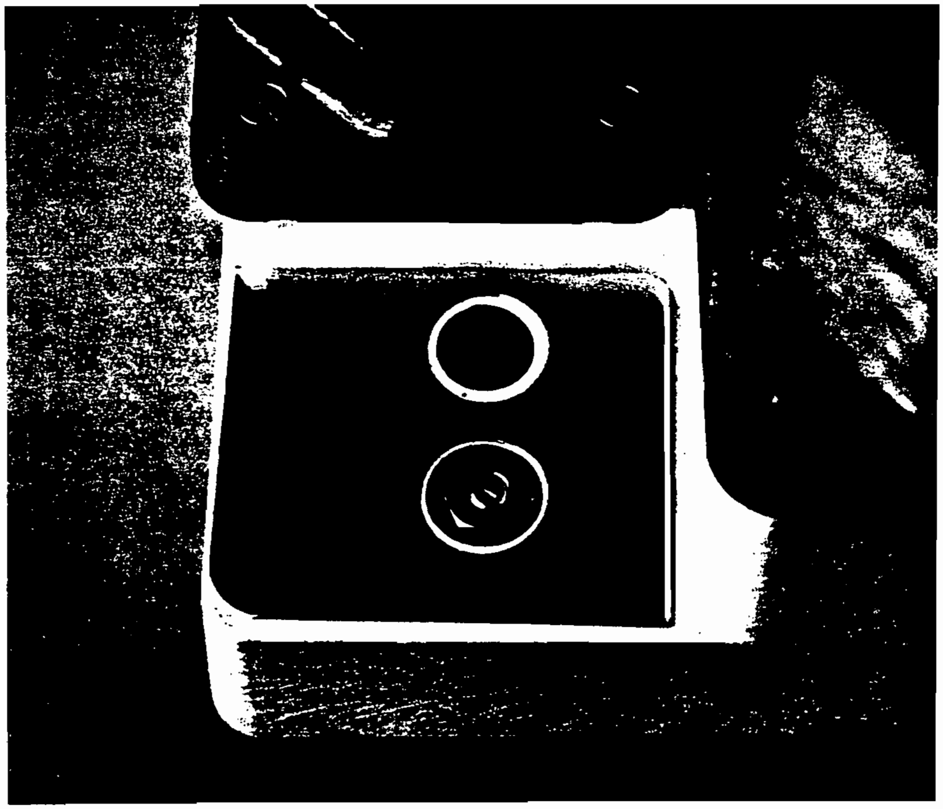


Figure 17
Primary Zero Adjustment



4 Operation and Maintenance

4.1 Primary Zero Adjustment

The primary zero adjustment (PZA) establishes the zero flow signal. The potentiometer and a zero indicator light (a red/green LED) are used to adjust the primary zero. An absolute zero setting totally extinguishes the zero indicator. As the setting deviates either high or low from actual zero, the indicator blinks red or green, depending on the offset direction. The further the adjustment deviates, the more rapidly the indicator blinks. One blink per second represents a zero error of approximately 0.03% of the calibrated maximum full scale flow rate, well within acceptable tolerances for most applications. A steady red or green light with no flow indicates a large deviation from actual zero and requires adjustment of the PZA.

Note: During normal forward flow the light will be steady green. During reverse flow, the light will be steady red.

After installation, **follow these steps** to set the primary zero:

1. Apply power and run fluid through the meter for about 15 minutes to reach normal operating conditions.

2. Shut off fluid flow at a downstream valve, making sure the sensor tubes remain full of fluid and contain no trapped air or gases. A partially filled sensor tube can result in an inaccurate zero setting and, consequently, an inaccurate output signal.

3. Observe the zero indicator. If the light is out or blinking (red or green) less than five times per second, the PZA is within an acceptable range. If the indicator is red, turn clockwise; if green, turn counterclockwise. In either case, adjust until the zero indicator blinks a maximum of five times per second. Run flow and repeat steps 2 and 3.

Note: This adjustment is independent of flow direction.

Test the mount of the D6 and D12 sensors by applying heavy and continuous hand pressure to each of the four mounting points and the process connections. If the primary zero indicator varies significantly when pressure is applied to any point, the installation is inadequate. Remount the sensor unit.

Once the flow meter has been properly mounted and the primary zero adjusted, the meter is ready for operation. If desired, conduct a flow test to verify factory calibration. Section 4.3 outlines this easy performance check.

After setting the primary zero do not readjust it between batches. A blinking light indicates an adequate zero setting. When the flow is shut off for several hours, the zero indicator may display a steady green or steady red light. This is because entrained gases may come out of the process solution within the flow tubes. This is not a reason for concern, unless the gas in the tubes causes erratic performance. Resumption of flow should remove the gas pockets.

Caution: With forward flow/steady green light or reverse flow/steady red light, check for erratic output. To diagnose and correct erratic output follow the steps given in Section 4.5, Table 7.

NOTE: DO NOT READJUST THE PRIMARY ZERO.

4.2 Factory Preset Adjustments

All items except the primary zero adjustment are factory preset. This section provides a brief description of the adjustable items. Also, it refers to other sections of the manual which contain additional information on their use. Appendix III provides assembly drawings and schematics. The adjustable items are clearly identified on the assembly drawings.

The time constant and frequency cutoff potentiometers are preset to factory standards rather than customer specifications. At installation, these may be reset, although normally they require no readjustment. Procedures are discussed in Section 5.3.2.

4.2.1 Span Select Switch

This switch, located on the signal board, sets the span of the meter. The sensitivity of the individual meter is determined. Then, the switch is set for the amount of amplification necessary to achieve maximum specified output on the frequency board or the maximum output on the analog board at the desired maximum full scale flow rate (Section 5.4.1).

4.2.2 Time Constant Potentiometer

Located on the signal board, this adjusts the meter response time from 0.1 to 1.1 seconds. It can be increased from the factory setting of 0.3 seconds to filter out low-level noise (Section 5.3.2.1).

4.2.3 Frequency Range Switches

This scales the calibrated flow rate signal to the desired frequency output percentage. The proper percentage of the 0-10,000 Hz is then sent from the frequency board to the output device (Section 5.4.2).

4.2.4 Frequency Cutoff Potentiometer

This disables frequency output below a predetermined value to limit low level noise. It disables 0.01% to 1.0% of the meter's calibrated maximum full scale flow rate. The factory presets this to approximately 0.3% (Section 5.3.2.2).

4.2.5 Zero Adjust Potentiometer

The zero adjust potentiometer is located on the analog board. (*Note: This is not the primary zero potentiometer.*) It sets the low end of the analog output (e.g. 0 mA, 4 mA, 0 VDC) (Section 5.3.1.2).

4.2.6 Range Adjust Potentiometer

This analog board potentiometer finely sets (± 5% adjustment) the high end of the analog output (e.g. 20 mA, 5 VDC) at maximum full scale flow rate (Section 5.3.1.2).

4.2.7 Output Select Switch

This allows the meter to be reset for different analog output interfaces (Section 5.3.1.1).

4.3 Performance Check

Run a performance check only after changing calibration switch settings, or if the meter is suspect. **Follow these steps:**

1. Check the primary zero setting at normal operating temperature and no flow conditions (Section 4.1).

2. **If** the meter is equipped with a flow totalizer:

a) Run an amount of fluid into a container at a flow rate close to the calibrated maximum rate; constant flow rate is not necessary. If the meter is calibrated in mass units/minute, the best results will be obtained if the test duration is about one minute.

b) Weigh the mass and compare the weighed mass with the totalized mass.

If the meter is not equipped with a flow totalizer:

a) Perform the flow test at a constant rate for a known duration of time to predict the total fluid mass delivered.

b) Weigh the fluid and compare weighed mass with predicted mass. If the metered or predicted mass and weighed mass agree within acceptable tolerances, the test is complete. If test results are not satisfactory, refer to Section 5.4 for a discussion of meter recalibration.

Note: Weighing apparatus, stop watch, meter mounting, zero offset, and control valve all contribute to system uncertainties. Make sure the test setup and procedure minimize, or account for, these variables.

The percent deviation between metered mass and weighed mass is numerically equal to the percent error at any flow rate. Verify repeatability by rerunning the test under the same conditions.

4.4 Preventive Maintenance

Maintenance requirements are minimal, as the meter contains no seals, bearings, or moving parts. Protect the remote electronics unit and sensor unit terminals from direct and repeated high-pressure washdowns, corrosive elements, or climatic extremes. Your factory representative can advise protective measures to shield the meter from potentially harmful environments.

The sensor unit is designed for clean-in-place or steam-in-place operations. Material buildup inside the sensor tube can be flushed away or ultrasonically cleaned as easily as other piping fixtures. Take care not to damage the sensor tube itself.

4.4.1 Precautions

To avoid damaging the sensor unit during steam cleaning, do not allow temperatures to exceed 400° F (200° C). Do not insert cleaning implements into the sensor tube since the sensor assembly may be damaged.

4.5 Corrective Maintenance—Troubleshooting

On new installations, most malfunctions result from mounting (D6 and D12), piping, or wiring problems. Check these items before attempting service on the meter. Also, the calibration setting should agree with the calibration data label. Use Figure 5 on page 11 to locate the various circuit boards.

Troubleshooting procedures for different meter problems are given in Sections 4.5.1 through 4.5.11. Table 7 outlines which procedures should be followed to correct the most common problems. Follow the procedures in the order given to expedite problem correction.

Danger: Some troubleshooting procedures require an operating flow meter. Exercise extreme care to avoid contact with live electrical parts, otherwise, personal injury or damage to meter components could result.

4.5.1 Input Power/Wiring

Incorrect wiring, power supply problems, or blown fuses may cause no output or erratic output. **Follow these steps** to isolate problems of this type:

1. Make sure the meter is on and fluid is flowing. (The zero indicator light will be lit.) If the zero indicator light is lit, the problem is not at the inputs; proceed to the next section suggested in the table. If the zero indicator does not light, continue with steps 2 through 6.

Table 7
Troubleshooting*

Problem	Troubleshooting Steps to Follow
No Output	4.5.1, 4.5.2, 4.5.3, 4.5.4
Erratic Output	4.5.1, 4.5.2, 4.5.3, 4.5.4, 4.5.5, 4.5.6, 4.5.7, 4.5.8, 4.5.9
Zero Instability	4.5.5, 4.5.6, 4.5.7, 4.5.8, 4.5.9
Calibration Error	4.5.10, 4.5.11, 4.5.5, 4.5.6, 4.5.7, 4.5.8, 4.5.9

*Follow troubleshooting steps in order given to expedite problem correction.

2. Remove the terminal covers and the electronics compartment cover.

3. Check both the incoming power connections (Section 3.6.1) and the signal wiring cable connections (Section 3.6.2.2) to be sure the meter is receiving power. Make any necessary corrections and observe the output.

Note: If DC power supply, check power source. Meter requires 1 amp minimum for startup.

4. Shut off flow and power to the meter.

5. Pull the input voltage board and check the fuses. Replace any blown fuses according to Section 4.6. Part numbers for replacement fuses are given in Section 6.2.

Note: The supply voltage must agree with the voltage stated on the input voltage board.

6. Check for signal continuity (Section 4.5.4).

4.5.2 Flow Direction Wiring

Check the flow direction wiring connections to terminals 13, 14, and 15 according to Section 3.6.3.1. If the wiring does not correspond to the flow direction, the analog output will decrease with increasing flow and the frequency output will not register. For units which display bidirectional flow, such as the Micro Motion DRT, the unit will display only forward flow, unless a jumper is installed between flow meter terminals 14 and 15.

4.5.3 Output Devices

If the meter is sending an accurate signal to the output displays, but the displays do not register, the problem is in the display device. The meter must be on and fluid flowing to check the output signal to the display devices.

Follow these steps to check the analog output:

1. Temporarily remove the analog board.

2. Check the accuracy of the output select switch setting (Section 5.3.1.1). If it is incorrect, change the setting, reinsert the board, and observe the output.

3. Disconnect the output wires.

4. If the output select switch is correctly set, but set for milliamps, pull the board and temporarily flip the select switch to deliver a voltage output.

5. Reinsert the analog board.

6. Connect a voltmeter to the analog output and return terminals (normally 17 and 16, respectively).

7. If the voltmeter registers an output corresponding to flow rate, disconnect and check the output device.

8. If the analog output decreases with increasing flow, check the flow direction wiring (Sections 4.5.2 and 3.6.3.1). If there is no apparent output, check the signal continuity (Section 4.5.4).

Note: If the meter output is in milliamps be sure to reset the select switch before reattaching the output device.

Follow these steps to check the frequency output:

1. Connect a frequency counter, such as a Micro Motion D10-RT, to the output and return terminals of the flow meter frequency output (normally 19 and 18, respectively).

2. If the frequency counter registers an output corresponding to flow rate, disconnect and check the output device.

3. If there is no apparent pulse output, first check the flow direction wiring, (Sections 4.5.2 and 3.6.3.1) and then check the signal continuity (Section 4.5.4).

4.5.4 Signal Continuity

The preceding steps isolated signal problems at the input and outputs. This section provides steps for following the signal through the meter, from the sensor unit to the isolation board within the electronics unit.

Follow these steps to check the position detectors and drive coil within the sensor unit:

1. Turn off power to the meter. If the installation makes this too difficult, remove the input voltage board being very careful not to touch any live connections or fuses.
2. Remove the safety board.
3. Check the resistance of the position detectors and drive coil with an ohmmeter or Micro Motion Resistance Tester. The leads of the ohmmeter should be connected to the following terminals:

To check:	Use:
Right position detector	terminals 6 and 8
Left position detector	terminals 6 and 7
Drive coil	terminals 1 and 2

4. Compare actual resistance values to the nominal values in Table 8. Values should be close to those indicated if the process is near room temperature. To calculate resistances at other temperatures, refer to the footnote in Table 8. More importantly, the two position detectors should have resistance values within 10% of each other. If not, the problem is within the sensor unit.

Note: There are no user serviceable parts in the sensor unit. Contact the factory.

Follow these steps to check the temperature sensor:

5. Check the temperature sensor by connecting the leads of the ohmmeter to terminals 6 and 9. The value should range between 95 and 112 ohms for room temperature applications. Refer to the Table 8 footnote to calculate resistance values for other temperatures.

Note: If the temperature sensor is open, the meter will indicate 30-50% lower than true flow rate. The temperature sensor is within the sensor unit; consult the factory for service.

Table 8
Resistance Chart*

	Sensor Size							
	6	12	25	40	100	150	300	600
Right Position Detector	750-850	274-335	274-335	274-335	274-335	274-335	274-335	86-105
Left Position Detector	750-850	274-335	274-335	274-335	274-335	274-335	274-335	86-105
Drive Coil	1476-1582	1268-1328	371-453	371-453	98-120	98-120	50-62	10-15

*These are nominal values at room temperature. Temperature alters resistance by 40% per 100° C. The actual resistance values will be higher or lower than the values shown, as temperature increases or decreases respectively.

Follow these steps to check the signal board:

6. Using a voltmeter, check for ±10 V and ±15 V on the test points (see Table 16 and Figure 44 in Appendix III). If any voltage is missing, replace the signal board. Refer to Section 6.2, Parts List, and Section 4.6, Component Replacement.

Follow these steps to check the drive board:

7. With the meter on and fluid flowing, use a frequency counter to check the pulse output. The pulses testpoint should indicate 0 pulses at no flow, ≅10,000 Hz at calibrated maximum full scale flow. Or, with a voltmeter, check for +1.5 to +9 VDC on the drive gain test point (see Table 15 and Figure 42 in Appendix III). Replace the drive board if there is no signal. Refer to Section 6.2, Parts List, and Section 4.6, Component Replacement.

Follow these steps to check the isolation board:

8. Check the fuses. Replace according to Section 4.6, if necessary. Order replacement fuses according to Section 6.2.

Caution: The isolation board fuses are 1/32 amp. Use a low milliamp ohmmeter when checking them, to avoid blowing the fuses.

9. Check for + 15 V on the isolation board test point. Use the negative side of component C400 (Figure 40) as reference ground. If no voltage is present, replace the isolation board. Refer to Section 6.2, Parts List, and Section 4.6, Component Replacement.

4.5.5 Primary Zero Adjustment

Check to be sure no air or gas bubbles have accumulated in the sensor tube during the adjustment process. See Section 3.3 for recommended sensor orientation. Also, the process fluid must not be flashing or boiling inside the sensor tubes. If these possibilities have been eliminated, adjust the primary zero according to Section 4.1.

4.5.6 Shutoff Valves

Check all in-line shutoff valves for leaks. Leakage could result in actual flow through the meter. A downstream shutoff valve is recommended to ensure actual zero flow when setting the primary zero adjustment.

4.5.7 Mounting (D6, D12)

With the meter on, no flow, and the primary zero properly adjusted, test the mounting of the meter by applying heavy and continuous hand pressure to each of four mounting points as well as the process connections. If the zero setting deflects when pressure is applied, the mounting or pipe supports may be transmitting vibrational stress to the sensor tube (Section 3.4.1).

4.5.8 Pipe Supports

The piping can occasionally resonate at the same frequency as the sensor tube assembly. Additional pipe supports prevent this problem (Section 3.5.1).

4.5.9 Low Level Noise

To filter out undesirable low level noise, such as extraneous vibration, refer to Section 5.3.2 for time constant and frequency cutoff potentiometer adjustments.

4.5.10 Calibration Settings

Compare the switch settings on the signal and frequency boards (Figures 44 and 36, respectively) to the calibration data label (Section 5.2). These should match, unless the application requirements have changed. If the application has changed, the switch settings should comply with the new requirements. If not, follow the recalibration procedures in Chapter 5. If the calibration settings are correct, but the measurement does not appear accurate, run a performance check (Section 4.3).

4.5.11 Recalibration

Section 4.2 describes the adjustable items on the meter. Any recalibration procedure (Chapter 5) should be followed by a performance check (Section 4.3).

4.6 Component Replacement

Circuit boards and fuses are easily replaced in the field. To order parts, refer to Sections 6.1 and 6.2.

Follow these steps to replace a circuit board:

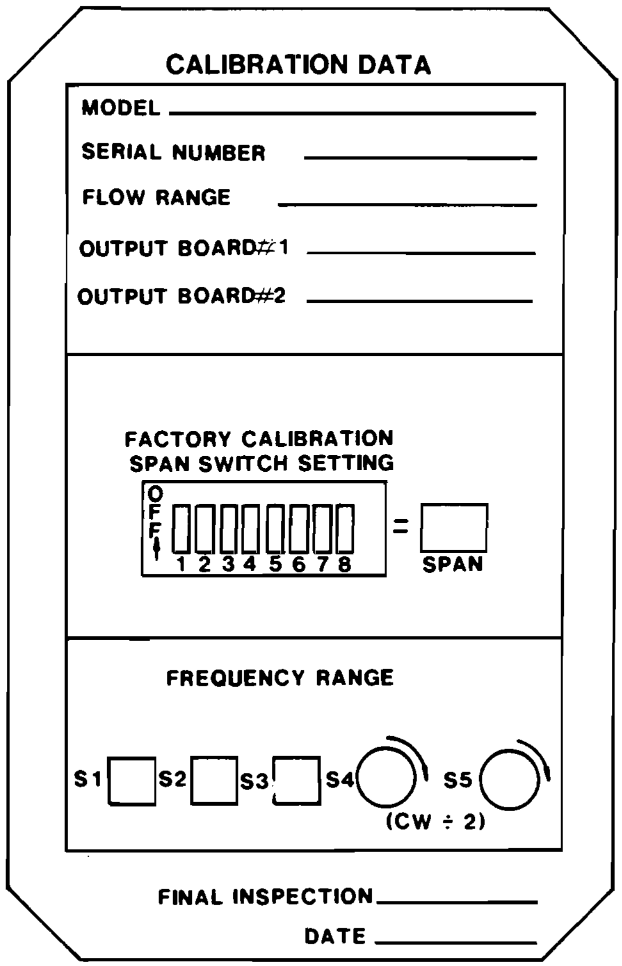
1. Shut off power to the meter.
2. Remove the remote electronics compartment cover.
3. Using Figure 5 on page 11, locate and remove the old board.
4. Using the old board or calibration data label (under compartment cover lid), duplicate the setting of any adjustable items. Adjustable items are clearly shown on the assembly drawings in Appendix III.
5. Carefully insert the new board.
6. Replace the cover.

Caution: When replacing boards, be sure to use the correct replacement. Be especially careful with D Meter safety and drive boards. They should have yellow tags identifying them as D Meter components.

Follow these steps to replace a fuse:

1. Shut off power to meter.
2. Remove the electronics compartment cover.
3. Remove the board on which the fuse is located.
4. Replace the fuse.
5. Reinsert the board.
6. Replace the cover.

Figure 18
Calibration Data Label



5 Recalibration

5.1 General

Initially, the mass flow meter is factory calibrated to customer specifications. Recalibration may later be necessary to accommodate different flow ranges or applications. Recalibration is a simple procedure since the meter output is linear without compensation.

Danger: Most calibration adjustments require an operating flow meter. Use extreme care to avoid contact with live electrical parts, or personal injury or damage to meter components may result.

Meter adjustments should be made by qualified personnel only.

5.2 Calibration Data Label

Figure 18 shows the calibration data label. It is located inside the large cover on the remote electronics unit and provides useful information for recalibrating the meter.

The model number provides information about the meter size and electronics.

The serial number is important when contacting the company for troubleshooting assistance or when ordering replacement parts.

The flow range indicates the factory calibrated full scale flow range.

In a dual output analog-frequency meter, the output boards will be set up as follows:

Output board #1 will be the frequency board. The label will show the calibrated frequency in hertz.

Output board #2 will be the analog board. The label will show the volt/milliamp selection.

In the case of a dual analog or dual frequency meter, the label shows the factory calibration of each board. Figure 5 on page 11 shows the location of the output boards.

The label shows the setting of the span select switch on the signal board. The switch position next to the numbers on the span select switch will always be the ON position. The label shows the factory setting of these switches with dashes on the switch diagram.

The frequency range portion of the label shows the setting of the frequency range adjustment on the frequency board. If the meter is a dual frequency meter, the label will show two switch diagrams. The upper diagram will be for output board #1 and the lower diagram will be for output board #2.

5.3 Minor Adjustments

5.3.1 Adjusting for Different Analog Output Interfaces

5.3.1.1 Output Select Switch. The analog output select switch determines whether the flow signal output will be in milliamps or volts, as well as specifying the range. This dual switch, labeled Output Select, is located on the analog board (Figures 34 and 35, Appendix III) and allows two select combinations. Switch 2 (the milliamp/voltage select switch) establishes milliamps output in the OFF position or volts output in the ON position. Switch 1 establishes the analog output range. The OFF position selects a range of 0-20 mA or 0-5 VDC. The ON position selects 4-20 mA or 1-5 VDC. These switches can easily be reset to accommodate different output interfaces. An analog output board with ranges of 0-50 or 10-50 mA, or 0-10 or 2-10 VDC is a standard option.

Note: When changing meter output interfaces, reset the select switches to the desired output and range. Also check the primary zero and analog zero and range adjustments.

5.3.1.2 Analog Zero/Range Adjust Potentiometers. The analog output board generates an analog output signal proportional to the mass flow rate. The analog zero adjustment sets the low end of the analog output. The range adjustment sets the high end of the analog output. The potentiometers, located side-by-side on the analog output board (Figures 34 and 35, Appendix III), allow fine tuning of their respective adjustments within ± 5% of the calibrated settings.

Follow these steps to recalibrate the analog zero and range adjustments:

1. Check both output select switch settings (Section 5.3.1.1).
2. Check the primary zero adjustment (Section 4.1).
3. Disconnect wires to the analog output device. Connect a milliammeter or voltmeter to the analog output terminals.
4. With the sensor tubes full of fluid, no flow, and the PZA adjusted, set the zero adjust to show the appropriate (0 mA, 4 mA, 0 VDC, or 1 VDC) no-flow value. Turning the potentiometer clockwise increases the setting, while turning it counterclockwise decreases the setting.
5. At maximum calibrated flow, set the analog range adjust to show the appropriate (20 mA or 5 VDC) full scale flow value. Turning the potentiometer clockwise increases the setting, while turning it counterclockwise decreases the setting. A full turn will alter the meter range by approximately 1%. If a range error still exists when the adjustment has reached the end of its effect, the span select switch will have to be rescaled (Section 5.4.1).
6. Recheck the setting of both the zero adjust and range adjust. A performance check (Section 4.3) is also recommended to verify the accuracy of the new settings.

5.3.2 Filtering Low Level Noise

5.3.2.1 Time Constant Potentiometer. The time constant adjusts the response time of the meter output. It is used to filter undesirable output caused by fluctuations in flow rate. The time constant potentiometer (TC filter), located on the signal board (Figures 44 and 45, Appendix III), is an analog filter adjustable between 0.1 and 1.1 seconds (5-6 seconds optional). The TC filter is preset at the factory to approximately 0.3 seconds. To slow the response time, turn the TC filter clockwise; for a quicker response, turn the TC filter counterclockwise.

5.3.2.2 Frequency Cutoff Potentiometer. This 1% adjustment (10% is optional) disables frequency output below a predetermined value. It limits low level noise, which may be interpreted as flow by a digital totalizer near zero flow. The frequency cutoff on the frequency board (Figures 36 and 37, Appendix III) is preset at the factory to about 0.3%. It is adjustable between .01% and 1.0% of the meter's calibrated maximum full scale flow rate. Turning the frequency cutoff potentiometer clockwise increases the cutoff, while turning it counterclockwise decreases the cutoff percentage.

5.4 Recalibrating The Meter For Different Flow Rates

5.4.1 Span Select Switch

Note: Procedure for recalibrating the meter discussed below is different from recalibration procedures covered in manuals date previous to June, 1985. Both recalibration procedures are valid and only pertain to the span select switch (SSS).

The span select switch (SSS) establishes the overall calibrated full scale flow range of the meter. The factory presets the SSS for the amount of amplification necessary to achieve approximately 10,000 Hz output to the frequency board or maximum output on the analog board at the calibrated maximum full scale flow rate. To alter the flow range calibration by more than ±5%, the SSS must be rescaled. Since the adjustment is coarse (about 1%), follow rescaling with a performance check. Also, readjust the analog and frequency ranges.
The SSS is an 8-position bit switch located on the signal board (Figures 43 and 44, Appendix III). The switches on the SSS carry the values noted in Table 9 below, when they are in the OFF position.

Table 9
Span Select Switch Values

Switch Number	1	2	3	4	5	6	7	8
Value	.1	.2	.4	.8	1.6	3.2	6.4	12.8

For example, suppose switches 3,7, and 8 are OFF. Their values are .4, 6.4, and 12.8, respectively. Therefore, the meter span is 19.6, since:

$$.4 + 6.4 + 12.8 = 19.6$$

Note: The switch position next to the numbers on the span select switch is always the ON position. The calibration data label shows the factory setting of these switches with dashes on the switch diagram.

Follow these steps to rescale the meter range, determine the new span and reset the SSS:

1. Calculate the new SSS setting using the formula below:

$$N_2 = [F_1/F_2 \ (N_1 + 1)] - 1$$

Where
N_2 = New SSS setting
N_1 = Initial SSS setting
F_1 = Initial calibrated maximum flow rate
F_2 = Desired maximum flow rate

Note: If N_2 is greater than 25.5, or a negative number, the desired flow rate is outside the range possible for the sensor size.

2. Turn all switches on. Then, refer to Table 9 to determine which switches must be turned off. The correct combination of switches is obtained by starting with the highest switch value less than or equal to the new span value (N_2). Turn this switch on and subtract its value from the new span . Repeat this procedure with each successive highest remaining switch value, but subtract from the preceding difference, rather than from the span. Continue until the final difference is zero.

3. Run a performance check (Section 4.3) and recalibrate the analog and frequency ranges (Sections 5.3.1.2 and 5.4.2.1, respectively).

For example, suppose the initial SSS setting (N_1) is 19.6 (switches,3,7,8 are OFF), the initial calibrated maximum flow rate (F_1) is 15 lbs/min, and the desired maximum flow rate (F_2) is 20 lbs/min.

Use the formula in step 1 to determine the new SSS setting:

$$N_2 = [15/20\ (19.6 + 1)] - 1$$
$$N_2 = 14.45 \cong 14.5$$

Refer to step 2 to determine the correct combination of switches for the new span select switch value (N_2) of 147. Turn off and subtract the highest successive switch values until the final difference is zero:

Switch 8 is OFF since 14.5 − **12.8** = 1.7
Switch 5 is OFF since 1.7 − **1.6** = .1
Switch 1 is OFF since .1 − **.4** = 0

5.4.2 Frequency Range Switches

The frequency output section of Appendix II provides calibration suggestions for connecting the frequency output to specific devices. The frequency range switches (frequency board, Figures 36 and 37, Appendix III) scale the flow rate signal to the proper output percentage. For example, if a customer requests 1,700 Hz output at calibrated maximum full scale flow, the signal from the drive board (approximately 10,000 Hz) must be scaled to 17% before it is sent to the output device. The frequency range consists of five switches which perform the scaling operation. The five switches operate in the following manner:

S1, S2, and S3 are 10-position rotary switches which together form a fine adjustment multiplier. They allow a percentage of the primary flow signal to pass on to binary divider switches S4 and S5.

Switches S4 and S5 form a single rotary switch which divides the flow signal input by $2^{(N-1)}$. N is the position number (1-13) of the switch.

Note: As the setting of switches S4 and S5 increases, the frequency output decreases.

When switch 4 is at position 1, the maximum output frequency is approximately 10,000 hertz. At position 2, the maximum output frequency is approximately 5,000 hertz. The output frequency is halved successively, until the final switch setting of 13. At position13, the maximum output frequency is 2.5 hertz. Table 10 shows the setting of switches S4 and S5 for different frequency output ranges.

Note: If S4 is set between 1 and 8, the setting on S5 does not matter. However, if a setting between 9 and 13 on S5 is desired, line up the arrow in the center of S4 with the arrow on the board. This engages S5.

For example, the five switches may be set as follows for a frequency output of 1,700 hertz at the calibrated maximum full scale flow rate:

S1 = 6
S2 = 8
S3 = 3
S4 = 3
S5 is not engaged

Switches S1-S3 are a percentage multiplier (S1 = 6, S2 = 8, and S3 = 3). In this case, they allow 68.3 % of the flow signal to pass on to divider switches (S4 and S5). Switches S4 and S5 are set at 3 and thus divide the flow signal input by $2^{(3-1)}$. The electronics perform the percentage multiplication first. However, it is easier to understand the scaling process by calculating the binary division first.

For this example, assume the actual frequency output at the calibrated maximum full scale flow rate is 9,956 hertz. Perform the binary division:

$$9956 \div 2^{(3-1)} = 2489$$

Then, calculate the percentage multiplication:

$$2489 \times .683 = 1700$$

The frequency range switches can be recalibrated for a different range or adjusted to correct a calibration error. The recalibration and adjustment procedures vary slightly and are outlined in Sections 5.4.2.1 and 5.4.2.2.

5.4.2.1 Frequency Range Recalibration.

Follow these steps to recalibrate the frequency switches for a different range:

1. Record the values of switches S1-S3 as a three-digit percentage value.

2. Record the initial maximum output in hertz. If the meter still has the factory preset calibration, this can be found on the calibration data label.

3. Determine the new setting of frequency range switches S1-S3, using the following formula:

$$N_2 = N_1 \ (F_2/F_1)$$

Where
- N_2 = New switch setting (S1-S3)
- N_1 = Initial switch setting (S1-S3)
- F_2 = Desired maximum output in hertz
- F_1 = Initial maximum output in hertz

4. N_2, the new switch setting of S1-S3, is the new percentage multiplier.The percentage multiplier has a maximum setting of 999 (99.9%). Use the largest percentage possible (over 50.0%) of the frequency output signal. Therefore, N_2 must fall between 500 and 999. If the new switch setting is not between 500 and 999, it must be changed.

To change N_2:

a) If N_2 is less than 500, multiply the value of N_2 by 2. This multiplies the frequency output percentage by 2.

b) If N_2 is greater than 999, divide the value of N_2 by 2. This divides the frequency output percentage by 2.

Note: Follow this step and step 5 carefully. Whenever N_2 changes according to this step, the setting of switches S4 and S5 will change according to step 5.

5. The new setting of N_2 according to step 3 produces the desired frequency output. Therefore, if the value of N_2 is changed according to step 4, the frequency output is no longer correct. Switches S4 and S5 compensate for the change.

When the change in the value of N_2 multiplies the frequency output by 2 (step 4a), switches S4 and S5 are used to divide the frequency output by 2.

When the change in the value of N_2 divides the frequency output by 2 (step 4b), switches S4 and S5 are used to multiply the frequency output by 2.

Thus, the final frequency output is correct. Table 10 shows the setting of switches S4 and S5 for different frequency output ranges.

To change switches S4 and S5:

5a) If the value of N_2 was doubled according to step 4a, turn S4 (or S5) one position clockwise. This divides the frequency output by 2.

5b) If the value of N_2 was halved according to step 4b, turn S4 (or S5) one position counterclockwise. This multiplies the frequency output by 2. The note in Section 5.4.2 describes the method for engaging S5.

6. Repeat steps 4 and 5 until N_2 falls between 500 and 999.

7. Reset switches S1-S3 to the new setting (the final N_2 value between 500 and 999).

8. Ordinarily the recalibration of the frequency range switches will be well within the accuracy specification, so no further steps are necessary. However, if the frequency recalibration was preceded by recalibration of the span select switch, perform steps 1-5 of Section 5.4.2.2 to verify the new setting. If a minor calibration error exists, perform steps 6-11 of Section 5.4.2.2 also.

For example, starting with step 1 above, suppose S1 = 6, S2 = 8, and S3 = 3. Then, the switches have an initial three-digit percentage multiplier value of 683 (68.3%). Assume the initial maximum output is 1,700 Hz. The example in Section 5.4.2 explains how the initial setting of the switches corresponds to the frequency output at calibrated maximum full scale flow. The desired frequency output for this example is 3,000 Hz.

Use the formula in step 3 to determine the new frequency range switch setting:

$$N_2 = 683\ (3000/1700) = 1205$$

Following step 4, N_2 = 1205, or 120.5%. For the initial calibration, 68.3% of the 2,489 hertz was required to output 1,700 hertz (Section 5.4.2 example). To output 3,000 hertz would require 120.5% of the 2,489 hertz, which is not possible with a three-digit multiplier. Therefore, according to step 4b, divide the value of N_2 by 2.

$$1205 \div 2 = 603$$

Because of the above step, the percentage multiplier is now set to multiply the 2,489 hertz by 60.3%.

$$2489 \times .603 = 1500.8$$

This is slightly more than half of the desired frequency output. Therefore, according to step 5b, turn switch S4 (set at 3) one position counterclockwise (to a setting of 2). This multiplies the flow signal (2,489 hertz) by 2.

$$2489 \times 2 = 4978$$

Consequently, the percentage multiplier is now set to multiply 4978 hertz by 60.3%.

$$4978 \times .603 = 3001.7$$

For step 7, reset N_2 to the three-digit percentage value of 60.3% (603): S1 = 6, S2 = 0, and S3 = 3.The frequency output at calibrated maximum full scale flow is now 3,001.7 hertz. Exactly 3,000 hertz cannot be obtained with this procedure, because the percentage multiplication must be rounded to three positions. Even so, the recalibration error is less than 0.1%, well within the accuracy specification of 0.4%. If you wish to verify the calibration, proceed with step 8.

Follow these steps, if the previous switch setting is unknown:

1. Locate the frequency range on Table 10, which includes the desired frequency output. Reset switches S4 and S5 to the position indicated.

1. Calculate the setting of switches S1-S3 according to the following formula:

$$N_2 = F_2/F_1$$

Where N_2 = New switch setting (S1-S3)
F_1 = Highest frequency within selected range
F_2 = Desired frequency output

The new N_2 is expressed as a three-digit percentage.

2. Reset switches S1-S3 to the new value.

3. At this point a minor calibration error will exist, because the signal from the drive board at calibrated maximum full scale flow is not exactly 10,000 Hz. Perform steps 1-11 of Section 5.4.2.2, Frequency Range Adjustment, to adjust for this meter factor.

For example, if the desired frequency is 3,000 Hz, then according to step 1 above, switches S4 and S5 should be set to position 2 (frequency output between 2,500 and 5,000 hertz).
Use the formula in step 2 to calculate the new setting of switches S1-S3 (N_2):

$$N_2 = 3000/5000 = .600$$

The new N_2 value expressed as a three-digit percentage is 600. Reset switches S1-S3 (S1 = 6, S2 = 0, and S3 = 0).
Adjust the new calibration according to Section 5.4.2.2.

Table 10
Frequency Output With Switch Position and Minimum On/Off Times

Frequency Output (Hz)	Switch S4/S5 Position	Min. On/Off Time (msec)
5,000-10,000	1	0.05
2,500-5,000	2	0.1
1,250-2,500	3	0.2
625-1,250	4	0.4
312-625	5	0.8
156-312	6	1.6
78-156	7	3.2
40-78	8	6.4
20-40	9	13
10-20	10	26
5-10	11	52
2.5-5	12	100
1.3-2.5	13	200

5.4.2.2 Frequency Range Adjustment.

Follow these steps to adjust the frequency range after recalibration or when a calibration error exists:

1. Check the primary zero setting at normal operating temperature with no flow.
2. Run fluid into a container at a flow rate close to the maximum.
3. Weigh the fluid and compare the weighed (reference) mass to the metered mass.
4. Record both mass quantities.
5. If the above procedure indicates a calibration error, perform steps 6-11 below. Otherwise, no adjustment is necessary.
6. Use the formula below to determine the new setting of frequency range switches S1-S3.

$$N_2 = N_1 (M_s/M_f)$$

Where
N_2 = New switch setting (S1-S3)
N_1 = Initial switch setting (S1-S3)
M_s = Scale mass (weighed)
M_f = Flow meter mass (metered)

7. N_2 must fall between 500 and 999.

To obtain a setting between 500 and 999:

7a) If N_2 is less than 500, multiply the value of N_2 by 2. This multiplies the frequency output percentage by 2.

7b) If N_2 is greater than 999, divide the value of N_2 by 2. This divides the frequency output percentage by 2.

8. Any change in the value of N_2 according to step 7 requires adjustment of switches S4 and S5.

To adjust switches S4 and S5:

8a) If the value of N_2 was doubled according to step 7a, turn S4 (or S5) one position clockwise. This divides the frequency output by 2.

8b) If the value of N_2 was halved according to step 7b, turn S4 (or S5) one position counterclockwise. This multiplies the frequency output by 2.

9. Repeat steps 7 and 8 until N_2 falls between 500 and 999.
10. Reset switches S1-S3 to the new setting (the N_2 value between 500 and 999).
11. Repeat steps 1-5 in this section to verify the new setting.

For example, assume steps 2 through 5 produce the following data:

The fluid mass weighs 100.0 lbs, the meter indicates 101.3 lbs, and the switches are set at 603 (S1 = 6, S2 = 0, and S3 = 3). Since the difference between the weighed mass and the metered mass exceeds the expected accuracy (± 0.4%), a calibration error exists. Steps 6-11 must be performed.

Use the formula in step 6 to determine the new setting of switches S1-S3:

$$N_2 = 603\ (100.0/101.3) = 595$$

If in following steps 7, 8 and 9, the new setting (595) falls between 500 and 999, then no adjustment of S4 or S5 is necessary. Simply reset switches S1-S3 to the new value. Thus, S1 = 5, S2 = 9, and S3 = 5.

Finally, verify this new setting according to steps 1-5 above.

6 Replacement Parts/Accessories

6.1 Ordering Parts or Returning Equipment

Your factory representative can recommend spare parts to have available to minimize downtime should any problem occur. Order replacement parts from your factory representative. Part names for all field replaceable parts are listed in Section 6.2.

If the flow meter must be returned to Micro Motion for any reason, **follow these steps** to ensure the most efficient processing:

1. Contact Micro Motion Customer Support at (303) 530-8426 prior to shipment and obtain a return materials authorization (RMA) number. The RMA number is valid for 90 days and must accompany each package being returned.

2. Carefully clean the sensor unit and flush out the tubes. Micro Motion is not equipped to handle residue from many fluids and may return the meter or assess a cleaning charge if this precaution is not taken. Fully document the fluid. Inadequate information will delay handling of the meter.

3. Enclose complete information about the material being returned including model and serial number, the reason for return, a return address, full documentation on the type of fluid, and if appropriate, a purchase order number to cover repair and shipping costs.

4. Pack the equipment carefully, using the original packing if possible.

5. Return the complete flow meter, including the remote electronics unit with all of the circuit boards and associated parts. Remove the conduit connections and all other parts not originally shipped with the meter.

6.2 Parts List

Place parts orders through your factory representative. All orders must include the model and serial number of the meter as well as the name of the component. Some components require additional ordering information as listed in the footnotes below. The field replaceable components are listed below:

Interconnect cable (specify PVC or Teflon, and quantity in feet)
Junction box
Remote electronics compartment base (specify UL, BVS, or CSA approval)
Remote electronics compartment cover
Input/Output terminal cover
Signal terminal cover
Input voltage board* (specify 100, 115, or 220 VAC or 12-30 VDC)
Drive board*
Safety board*
Isolation board*
Analog output board* (specify range)
Frequency output board*
Fuses**

6.3 Accessories

This manual contains complete instructions for the Micro Motion Model D10-RT Digital Indicator/Totalizer, as well as a brief description of some of Micro Motion's other accessory equipment. For further information on specific and other accessories, contact your factory representative.

*Use Figure 5 on page 11 to identify the board. Orders for replacement boards must include the assembly (ASSY), revision (REV), and serial (S/N) numbers. To locate these numbers refer to the appropriate assembly drawings in Appendix III.
If the original board required custom engineering, the replacement order must include the CEO number. It will be marked on the board (usually near the revision number).
**The list below provides the fuse numbers and quantity required for each board:

Board	*Fuse Number*	*Quantity*
Isolation	312.031 3AG 1/32A	2
Input Voltage Boards		
100 VAC	312.031 3AG 1/4A	2
115 VAC	312.031 3AG 2/10A	2
220 VAC	312.031 3AG 1/10A	2
12-30 VAC	312.031 3AG 2/10A	1
	Littel # 273002	1

Figure 19
D10-RT Digital Rate Indicator and Totalizer

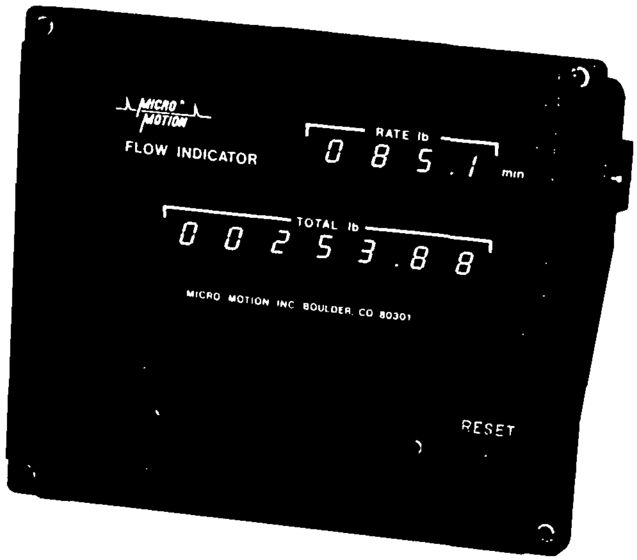
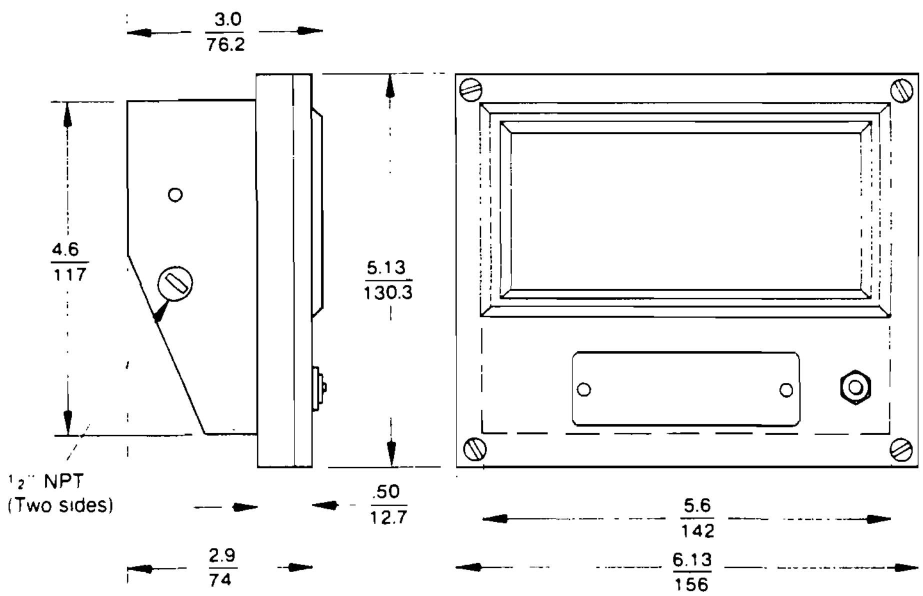


Figure 20
D10-RT Dimensions

dimensions: inches / mm



This drawing contains unit dimensions; panel cutout dimensions are shown in Figure 23.

6.4 D10-RT Digital Rate Indicator /Totalizer

6.4.1 General

The D10-RT digital rate indicator and totalizer operates in conjunction with the Micro Motion Mass Flow Meter. The D10-RT features a four-digit LED rate display and a seven-digit total mass display. The unit may be calibrated to display in a variety of mass units per time units (e.g. lbs/hour, kgs/min, etc.), although display face is labeled for the mass/time units ordered. The indicator also features solid state circuitry for high reliability. Options are available which allow remote activation of the manual reset, and which allow the totalizer to be inhibited or enabled without affecting the rate display. Table 11 summarizes the D10-RT's specifications:

Table 11
D10-RT Specifications

Power Requirements	100, 115, 220 VAC, or 8-24 VDC, 5 watts.
Frequency Input Requirements	
High	4.0 to 5.0 volts
Low	0.0 to 1.0 volts
Frequency Response	1-100k Hz
Sample Rate	0.2 to 2.0 seconds
Operating Temperature	-4°F to 158°F (-20°C to 70°C)
Enclosure	NEMA IV Aluminum
Shipping Weight	4 pounds
Dimensions	See Figure 20

6.4.2 Circuit Description

The Micro Motion D10-RT contains two circuit boards: a power board and a logic board. The power board (Figure 21) contains a fuse, a transformer, and a 5 VDC voltage regulator circuit. Switch S1 allows a selection of either an AC or DC power supply. The power board is secured to the D10-RT housing and is not replaceable.

The logic board (Figure 22) is divided into two sections. One section converts the input signal to a rate display. Switch S1 selects the position of the rate decimal point. Switch S2 is the sample rate adjustment. This setting provides for a rate display update every 0.2 or 2.0 seconds. Switch S3 is the time base compensator; it divides the input signal by 1, 6, or 36, depending upon the desired display units. Switch S4 selects the totalizer decimal point position. Switch S5 is the totalizer reset button located on the front of the D10-RT.

Figure 21
Power Board Component Layout

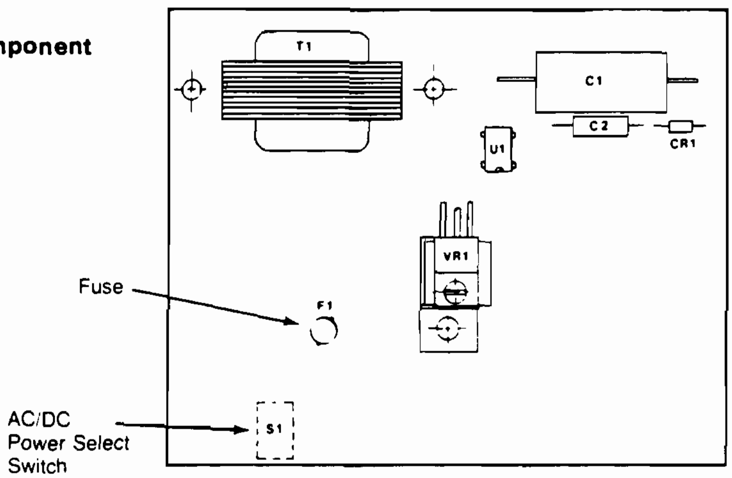
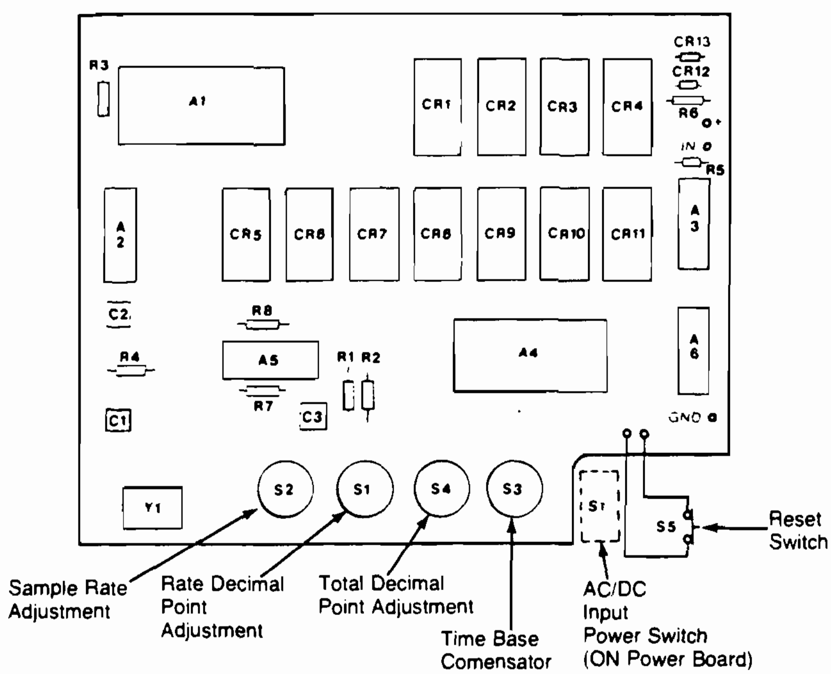


Figure 22
Logic Board Component Layout



6.4.3 Installation

6.4.3.1 Mounting. To mount the D10-RT on a wall or table top use the mounting brackets provided. Tilt the unit to the desired viewing angle and tighten the screws to lock the unit in place. Or, panel mount the D10-RT through a 4.7 × 5.7 inch cutout. The mounting brackets should be turned to attach the indicator to the panel (Figure 23).

6.4.3.2 Wiring. Wiring connections for the D10-RT are made through the ½ inch NPT tapped conduit holes provided in the sides of the case. Remove the rear access cover and locate the power input terminals, the signal input terminals, and the fuse (Figure 24). The indicator has been preset at the factory, for customer specifications, to accept a 110 VAC, 220 VAC, or 8-24 VDC power supply. In the AC power mode, terminals 1 and 2 are the input connections and terminal 3 is earth ground. In the DC power mode, terminal 1 is positive, terminal 2 is negative, and terminal 3 is case ground.

The frequency output from the mass flow meter is connected to terminals 5 and 6. Terminal 6 is the positive input terminal. It is connected to the corresponding output terminal of the flow meter (typically terminal 19). Terminal 5 is the signal ground and is connected to the corresponding return terminal of the flow meter (typically terminal 18). Terminal 4 is case ground and is connected to terminal 13 of the flow meter.

Caution: Before power is applied to the D10-RT, verify agreement between the supply voltage and the voltage stated on the label next to the power input terminals. Failure to observe this precaution could damage the electronic components or blow the fuse.

6.4.4 Operation and Maintenance

6.4.4.1 Operation. The Micro Motion D10-RT can be used with any Micro Motion Mass Flow Meter equipped with a frequency output. The frequency output is displayed as a flow rate. It is also integrated to provide a totalized flow display in desired mass units, as well as desired time-base units (seconds, minutes, hours). The rate display is a four-digit frequency indicator with 1 Hz resolution.

6.4.4.2 Maintenance. The D10-RT requires no periodic maintenance. The indicator should be shielded from repeated washings and hazardous or corrosive environments. Your factory representative can suggest protective procedures.

6.4.5 Adjustments

All of the adjustable features (Figure 25) are preset by the factory. They are described here for recalibration purposes.

6.4.5.1 Rate Decimal Point Adjustment. To move the rate decimal point position, remove the cover plate. Insert a small flat head screwdriver into the appropriate access hole (Figure 25) and engage the 5 position rotary select switch. When the switch is rotated fully clockwise, the decimal point is in the far right position (0000.). Each counterclockwise position moves the decimal point one place to the left.

6.4.5.2 Sample Rate Adjustment. The factory presets the D10-RT to update the rate display every two seconds. It counts the incoming frequency signal for one second and then displays the updated flow rate during the following second. Alternatively, the display may be updated every 0.2 seconds if desired. However, when in this fast sample mode, the least significant digit is dropped from the display. **For example,** a flow rate of 25.01 kg/min would be displayed as 25.0 kg/min.

To adjust the sample rate, remove the cover plate. Insert a small flat head screwdriver into the appropriate access hole (Figure 25) and engage the rotary select switch. The three clockwise positions of this five position switch all select the 2.0 second rate. The remaining two positions select the 0.2 second rate.

Note: When changing to the fast sample mode, shift the rate decimal point one position to the right as described in the rate decimal point adjustment, Section 6.4.5.1. Neither sample rate setting has an effect on the totalizer display.

Figure 23
D10-RT Mounting Diagram

dimensions: inches / mm

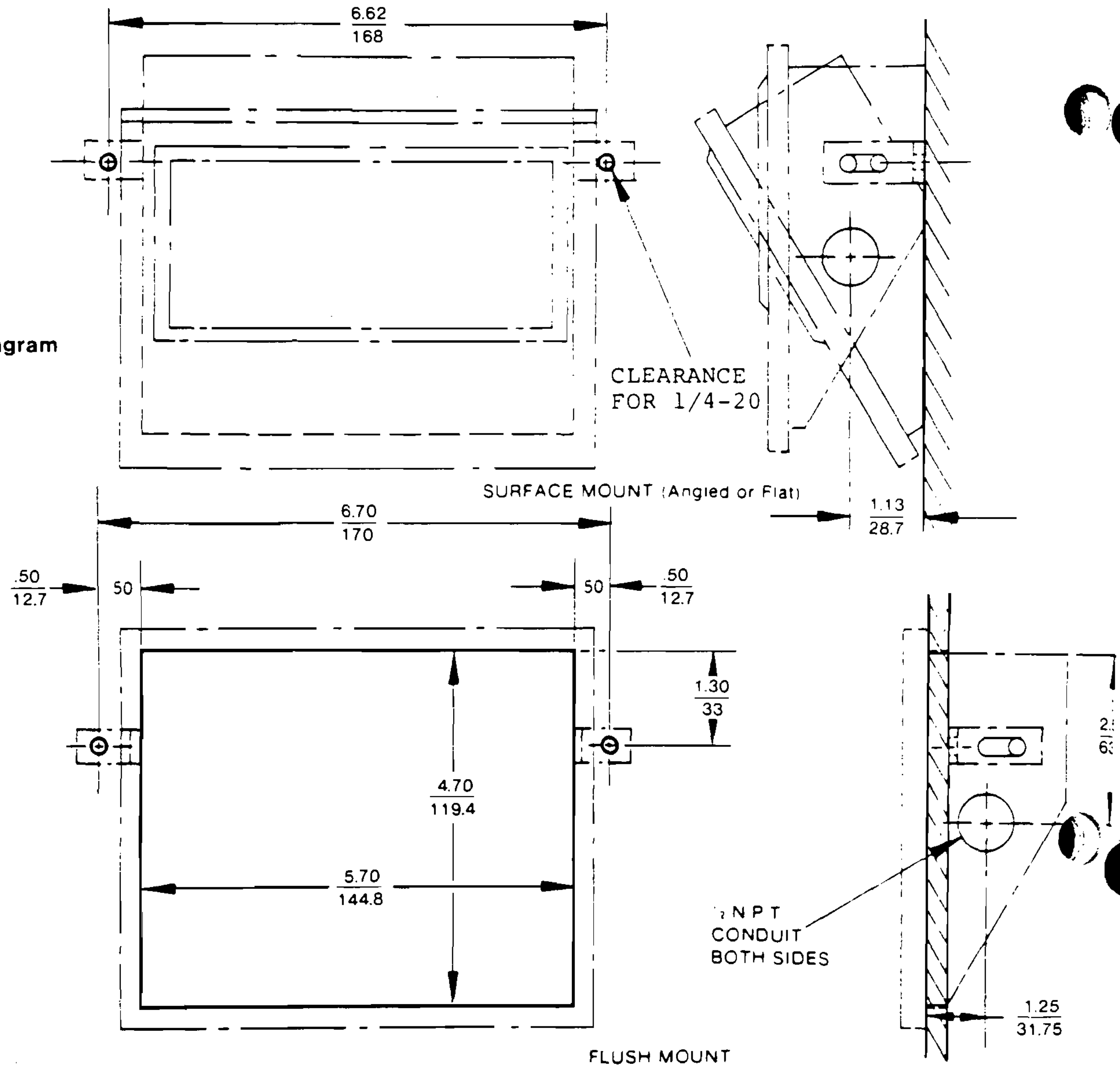


Figure 24
D10-RT Wiring Connections

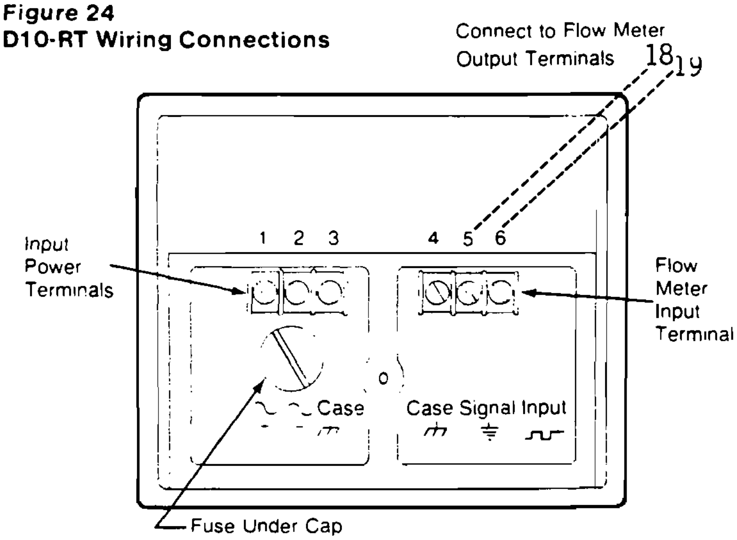
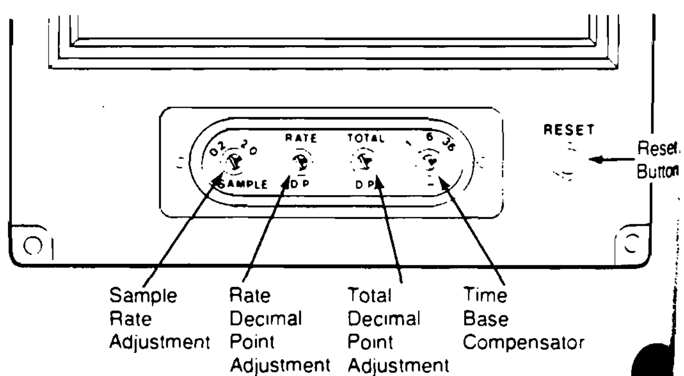


Figure 25
D10-RT Adjustments



6.4.5.3 Time Base Compensator Adjustment. The incoming flow rate signal may be scaled to mass units per second, minute, or hour. The Time Base Compensator (TBC) is used in conjunction with the totalizer decimal point adjustment to display in the desired time base units. Table 12 shows the compensator setting and corresponding totalizer decimal point position for each time base. The TBC internally provides a divider to convert the rate value to a total mass display.

Table 12
Time Base Compensator Adjustments

Time Base	*TBC Setting*	*Totalizer Dec. Point Position*
Second	1	Same as rate
Minute	6	Shift decimal point one place to left of rate position
Hour	36	Shift decimal point two places to left of rate position

The TBC internally provides a divider to convert the rate value to a total mass display. Selection of the TBC setting is best expressed by the following examples:

Example 1:
Calibrated flow rate = 0-10 lb/sec
Frequency output = 0-1000 Hz
Rate decimal point setting = 00.00
TBC setting = 1
Totalizer decimal point setting = 00000.00

Example 2:
Calibrated flow rate = 0-100 lb/min
Frequency output = 0-1000 Hz
Rate decimal point setting = 000.0
TBC setting = 6
Totalizer decimal point setting = 00000.00

Example 3:
Calibrated flow rate = 0-600 lb/hr
Frequency output = 0-6000 Hz
Rate decimal point setting = 000.0
TBC setting = 36
Totalizer decimal point setting = 0000.000

To select the proper time base, remove the cover plate. Insert a small flat head screwdriver into the appropriate access hole (Figure 25) and engage the rotary switch. For a compensator setting of 1, rotate the five-position switch to its fully counterclockwise position. A compensator setting of 6 is the middle switch position. A setting of 36 is attained by rotating the switch fully clockwise. Be sure to reset the totalizer decimal point to the corresponding position.

6.4.5.4 Totalizer Decimal Point Adjustment. To move the totalizer decimal point, follow the procedure described for the rate decimal point adjustment (Section 6.4.5.1).

6.4.6 Troubleshooting

6.4.6.1 General. Troubleshooting procedures are divided into three possible categories of malfunction:

6.4.6.2 No Output
6.4.6.3 Erratic or Unresponsive Output
6.4.6.4 No Rate/Total Correlation

Identify the section which most closely corresponds to the observed problem and **follow the steps** outlined. If none of the categories applies, consult your factory representative. The only field replaceable components in the D10-RT are the logic board and the fuse.

Note: When the D10-RT is first turned ON, some digits may not be lit. This condition is normal. As the unlit digit becomes a required part of the display, it will illuminate with the correct figure.

6.4.6.2 No Output.
Follow these steps if there is no output display on the D10-RT.

1. Check the input power supply operation and wiring.
2. Check the 2 amp fuse (Figure 24) and replace if necessary (consult your factory representative).
3. If the fuse was blown, check the AC/DC switch on the power board (Figure 21) to ensure proper input power selection.

Note: The front cover must be removed to locate the switch.

6.4.6.3 Erratic or Unresponsive Output.
Follow these steps if the D10-RT output is erratic or unresponsive:

1. If the D10-RT is mounted remote from the flow meter, temporarily relocate it near the meter. If this corrects the problem, check the signal wiring for electrical interference. A shielded signal cable and a larger gauge wire may be required.
2. If the problem persists, disconnect the signal wires from the flow meter and short them together rapidly and repeatedly. If the indicator does not respond, consult your factory representative.
3. If the D10-RT responds to Step 2 above, but not to the meter input, proceed with troubleshooting procedures on the flow meter (Section 4.5).

6.4.6.4 No Rate/Total Correlation.
Follow these steps if there is no correlation between rate and total:

1. Check the setting of the time base compensator. Also, check the position of the rate and total decimal points.
2. Run a performance check (Section 4.3) noting the average rate and duration of the test. If the total mass (computed by multiplying the average rate times the duration of the test) does not approximate the totalizer value, consult your factory representative.

6.5 **PI 4-20 Process Indicator**

The PI 4-20 process indicator converts analog loop signals directly into digital units. 3½ digit readout in ½ inch high LCD fits 2¼ inch square cutout. It is powered entirely by the 4-20 mA signal it measures. Intrinsically Safe design. Factory calibrated to desired specifications.

Table 13
PI 4-20 Process Indicator Specifications

Input Signal	4-20 mA calibrated range 2-30 mA functional range
Power Requirements	None other than the 4-20 process signal being measured
Input Resistance	Equivalent to 250Ω load (5V drop at 20 mA)
Output	3½ digit LCD, ½" high numerals
Output Range Adjustability	0-200 to 0-1999 counts
Output Zero Adjustability	0 ± 10% of output range
Linearity	± 1 count
Operating Temperature	32°F to 158°F (0°C to 70°C0)
Storage Temperature	−40°F to 212°F (−40°C to 100°C)
Shipping Weight	3 ounces

Figure 26
PI 4-20 Process Indicator

6.6 DT-7 Liquid Densitometer

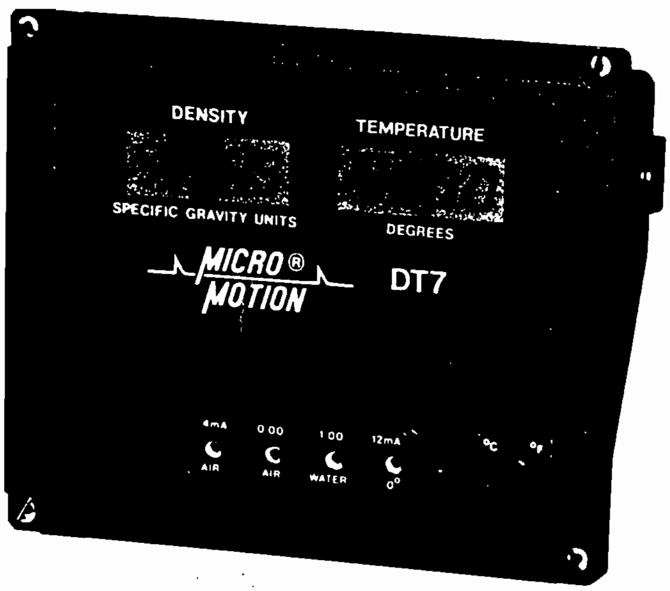
The DT-7 Liquid Densitometer directly displays both specific gravity (density relative to water) and temperature of the process fluid when used with any Micro Motion Model D mass flow meter. The DT-7 converts the flow sensor's natural frequency of vibration into a signal proportional to the process liquid's specific gravity over the range 0.00 to 3.20 S.G.U. User selected Celsius or Fahrenheit temperature indication ranges from −200° to +200°. The DT-7 has 4-20 mA outputs of both specific gravity and temperature. These outputs are available in a variety of spans, with adjustable zero offsets.

Table 14
DT-7 Liquid Densitometer Specifications

Accuracy	Specific gravity: ± 0.01 S.G.U. Temperature: ± 1°C*
Operating Temperature	−400°F to 400°F (−240°C to 200°C)
Electronics Temperature	−40°F to 150°F (−40°C to 65°C)
Analog Output Signals	4-20 mA specific gravity: Spans of .2, .4, .8, or 1.6 S.G.U. Zero offset from 0.0 to 1.6 S.G.U. 500 ohm max load. 4-20 mA temperature: Spans of 80°, 160° or 200°. Zero offset from −200° to +100°. (User selectable °C or °F). 500 ohm max load.
Output Displays	Specific gravity display: 0.00 to 3.20 S.G.U (Water = 1.0 S.G.U.) Temperature display: −199.9° to 199.9° (User selectable °*C or* °F)
Power Requirements	100-115, 220 VAC ± 10%, 3 watts
Enclosure	NEMA IV, Aluminum
Shipping Weight	3 pounds

The accuracy of the temperature readout may vary when used with the D6 and D12 flow meters, because the temperature detector is not placed in direct contact with the sensor tubes in these two models.

Figure 27
DT7 Liquid Densitometer



Appendix I
Detailed Theory of Operation

Introduction

Micro Motion measures mass directly. Fluid mass has a linear velocity as it flows through the sensor tube. Vibration of the sensor tube, at its natural frequency about an axis, generates an angular velocity as well. These vibrational tube forces, perpendicular to fluid flow, cause the fluid to accelerate on the inlet side and decelerate on the outlet side. The fluid exerts an opposing force of its own which resists the perpendicular tube forces, causing the tube to twist. The mass flow meter electronics unit essentially measures this very small twist force induced by the flowing process fluid on the vibrating sensor tube. This fluid force is proportional to the mass flow rate (see Mathematical Derivation below). It is the same Coriolis force which causes air currents to circulate around the rotating earth. This force also creates the gyroscopic precession employed in navigational systems of ships and aircraft. The Coriolis force is the only significant force used in the Micro Motion method of mass flow determination.

Mathematical Derivation

The Model D meters contain two U-shaped sensor tubes. The mathematical derivation and figures below describe the relationship between mass flow and tube motion for a single sensor tube. The basic mathematics apply to the dual tube configuration as well.

Figure 28
Sensor Tube With Axes of Rotation

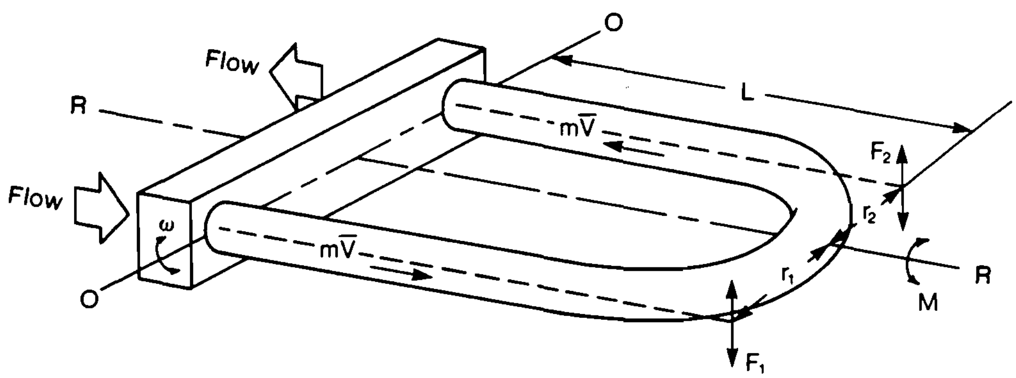


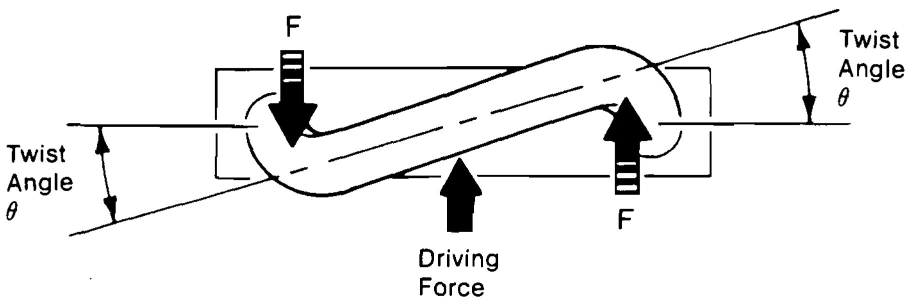
Figure 28 shows a fluid, having mass m and velocity V, moving through a sensor tube, which is rotating with angular velocity ω about axis O-O. The flow-induced Coriolis force is described by the following equation:

$$F = 2\, m\, \omega \times V \qquad (1)$$

Where F, ω and V are vector quantities, $\times$ is the vector cross product operator, and m is the quantity of mass contained in length L of the sensor tube. This equation is equivalent to F = ma (Newton's second law) in a rotational frame of reference.

The fluid inlet and outlet velocity vectors are opposite in direction. If the sensor tube is viewed from the end as two tube legs (looking into the R-R axis as in Figure 28), the forces F_1 and F_2 exerted by the fluid on the inlet and outlet legs are opposite in direction but equal in magnitude.

Figure 29
End View of Sensor Tube Showing Fluid Forces



As the tube vibrates about axis 0-0, the forces create an oscillating moment M about axis R-R, with radius r, which is expressed by:

$$M = F_1 r_1 + F_2 r_2 \quad (2)$$

Since $F_1 = F_2$ and $r_1 = r_2$, from equations 1 and 2:

$$M = 2 F r = 4 m V \omega r \quad (3)$$

Mass m is defined as the product of density ρ, cross sectional area A, and length L. Velocity V is defined as unit length L per unit time t. Mass flow rate Q is defined as the mass m which passes a given point per unit time t. That is, $m = \rho AL$ and $V = L/t$ and $Q = m/t$. Thus, by substitution, $Q = mV/L$, where L is tube length. Equation 3 then becomes:

$$M = 4 \omega r Q L \quad (4)$$

The moment M causes an angular deflection or twist, θ, of the sensor tube about axis R-R, which is at its maximum at the midpoint of vibrating tube travel (Figure 29). However, the deflection due to M is resisted by the spring stiffness k_s of the sensor tube. In general, for any torsional spring, the torque T is defined by:

$$T = k_s \theta \quad (5)$$

Since $T = M$, the mass flow rate Q can now be related to the deflection angle θ by combining equations 4 and 5:

$$Q = \frac{k_s \theta}{4 \omega r L} \quad (6)$$

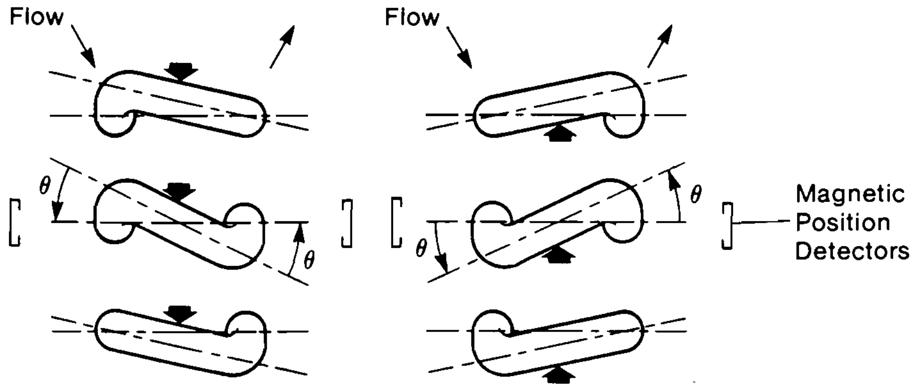


Figure 30
Complete Cycle of Sensor Tube Measurement of Twist Angle

The mass flow rate can be derived by measuring the deflection angle θ with two position detectors (Figure 30). Each detector measures θ as a function of the time at which each tube leg crosses the midpoint of tube travel. The time difference between the right and left legs on the up and down stroke crossings (seen as different pulse widths by the logic circuitry) is zero when there is no flow. But as flow increases, causing an increase in θ, the time difference Δt between the up and down stroke signals also increases. For more detailed information, refer to the Detection of Flow section.

The velocity V_t of the tube at the midpoint of travel, multiplied by the time interval Δt, is related to θ by geometry:

$$\sin \theta = \frac{V_t}{2r} \Delta t \qquad (7)$$

If θ is small, it is nearly equal to $\sin \theta$. And, for small rotation angles V_t is the product of ω and the tube length L. That is, $\theta = \sin \theta$ and $V_t = \omega L$. Thus equation 7 becomes:

$$\theta = \frac{\omega L \Delta t}{2r} \qquad (8)$$

Combining equations 6 and 8 gives:

$$Q = \frac{k_s L \omega \Delta t}{8 r^2 \omega L} = \frac{k_s}{8 r^2} \Delta t \qquad (9)$$

The mass flow rate Q is therefore proportional only to the time interval Δt and geometric constants. Q is independent of ω, and therefore independent of the vibrational frequency of the sensor tubes.

Detection of Flow

The deflection angle measurements are made near the midpoint of tube travel, where the tube velocity and the deflection angle are greatest and the angular acceleration is nearly zero. Two sets of time intervals, one from the downward and one from the upward tube movement are combined to produce a single data point. These techniques isolate the flow rate signal from tube-induced forces which could otherwise be interpreted as flow.

Figure 31 is a wave diagram depicting signal processing as performed by the logic circuitry under flow and no flow conditions. The sensor tube is again visualized from the end viewpoint as right and left legs of fluid flow, (incoming and outgoing). The magnetic position detectors measure the rectangular frequency waves. The right and left sensor signals are altered electronically (as represented by broad R and narrow L waves) to avoid signal overlap.

Thus, when the tube passes the midpoint on the upstroke, the right sensor signal is always detected before the left. Conversely, when the tube passes the midpoint on the downstroke, the left signal is always detected before the right. Again, this is due to the electronic alteration of the signals because, in reality, the sensor leg containing outgoing fluid always crosses the midpoint first on both the up and downstrokes (as in Figure 30).

The difference wave D, signals the differences between the times at which the right and left tube legs pass the midpoint on the up versus the down strokes. These pulse differences are sent to the linear integrator and integrated negatively for the upstroke pair and positively for the downstroke pair. When there is no flow through the sensor tube, the difference (wave D) pulse widths are equal in both directions. However, when fluid flows through the sensor tube there is a counterclockwise twist on the upstroke and a clockwise twist on the downstroke. This causes the two legs to cross the midpoint closer together in time on the upstroke and farther apart on the downstroke (relative to no flow conditions) so the difference pulse widths (wave D) are no longer equal.

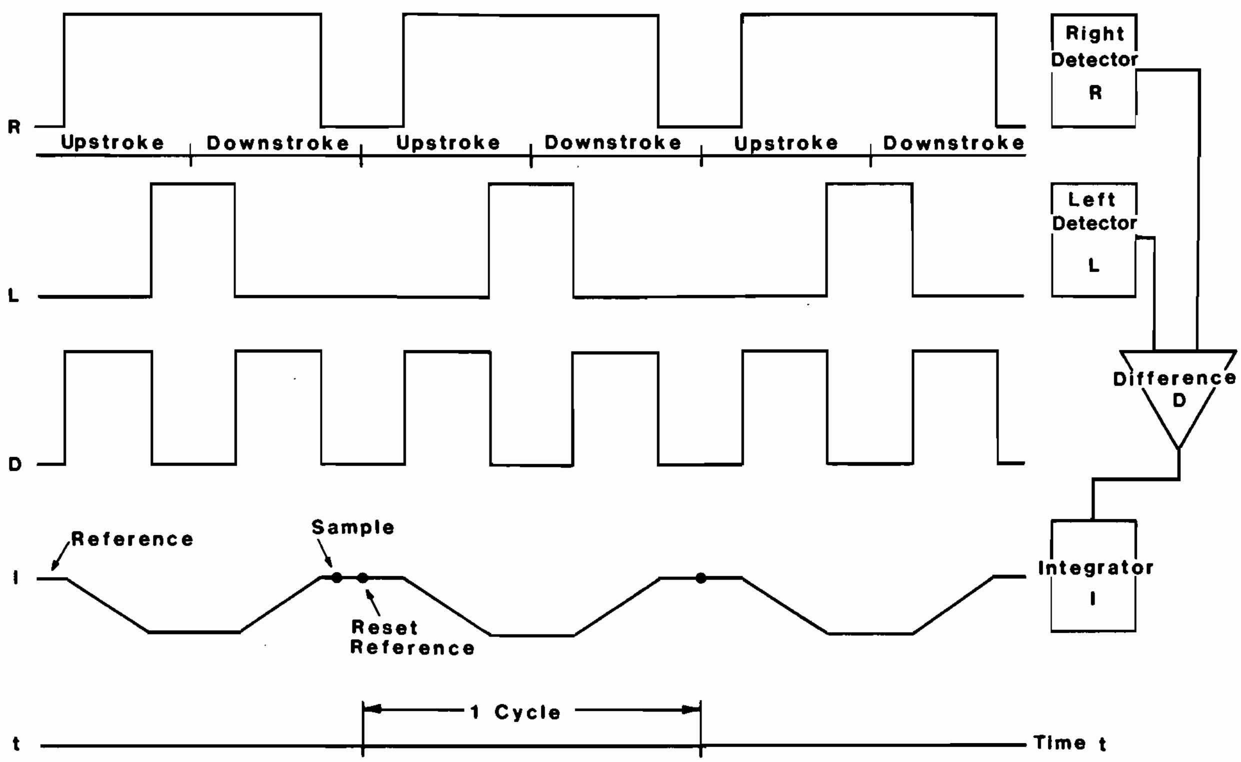
Since the integrated slopes are both equal and constant, normal forward flow conditions result in a net positive integrator output which is sent to a sample and hold circuit. The integrator output is sampled just before the reference level is reset and is in the hold mode for the rest of the cycle. This signal is linearly proportional to the time difference and thus, to the mass flow rate.

When the flow direction is reversed, the forces and direction of twist are reversed and the integrator output is negative rather than positive. The mass flow meter can therefore measure reverse direction flow as easily as forward flow.

Output Generation

Once the logic circuitry processes the signal, a 0-10,000 Hz pulse output is sent to the frequency and/or analog output boards. The frequency board scales the pulse signal for digital rate display, control and totalizing. The analog board converts the pulse signal to an analog voltage or current signal.

Figure 31
Wave Drawing
Depicting Signal Processing



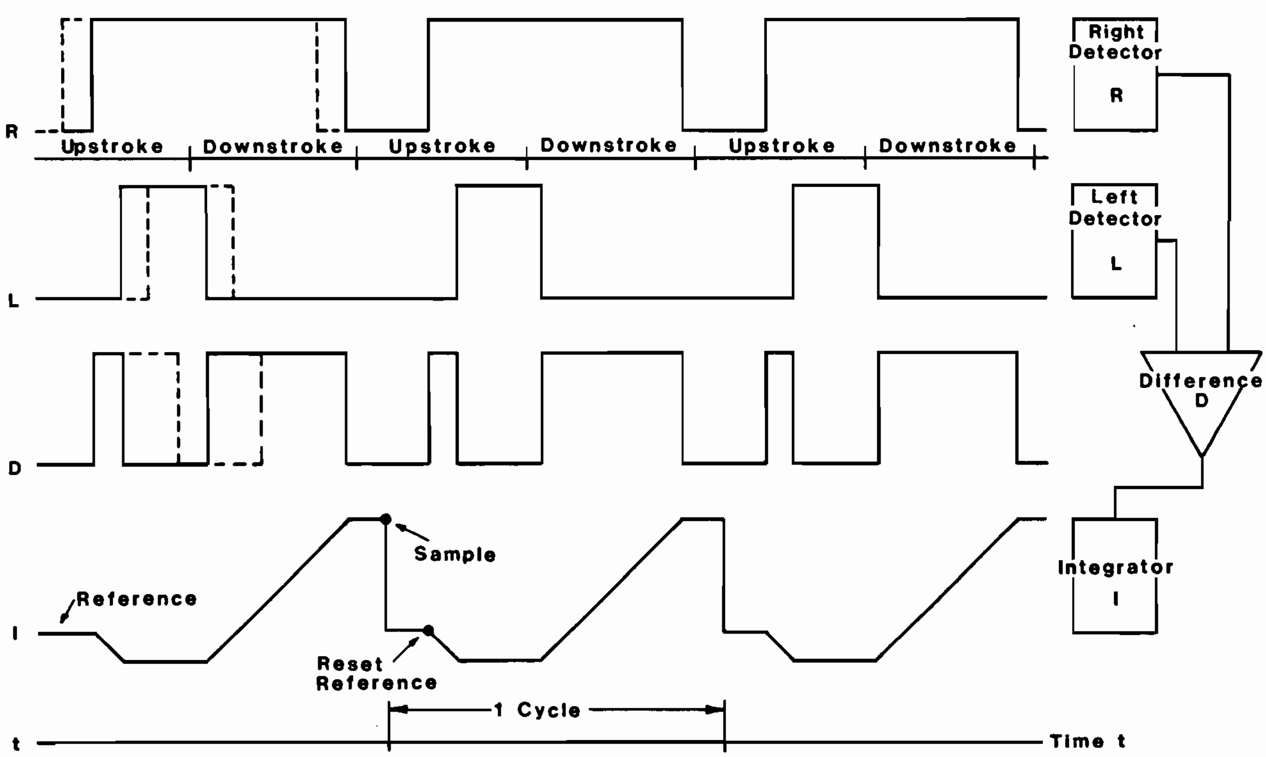
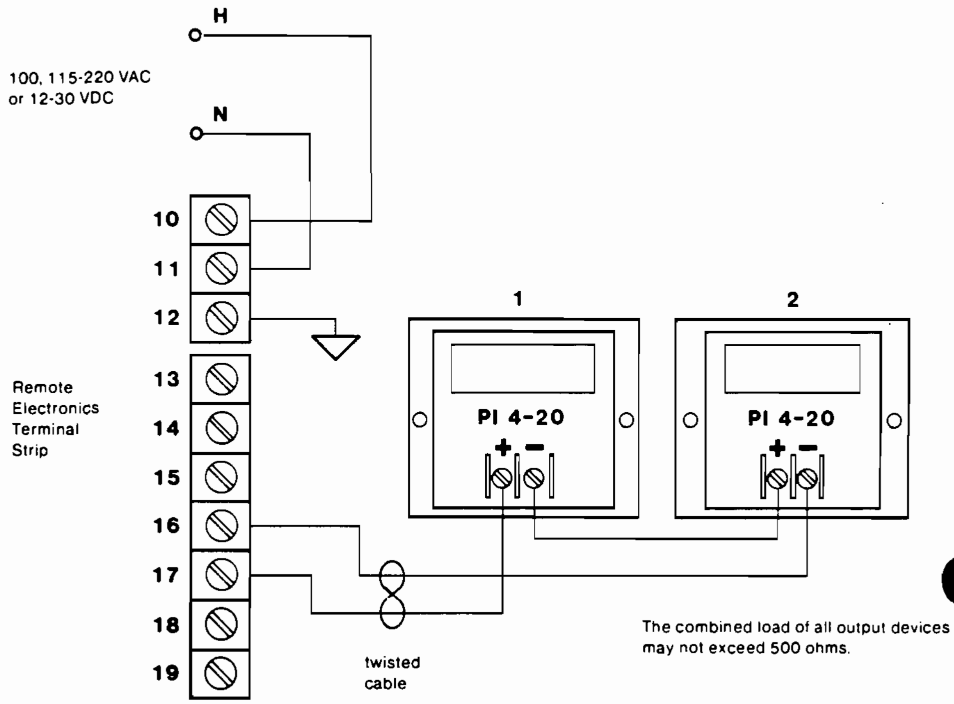


Figure 32
Analog Output Wiring



Appendix II

Analog Output

This appendix contains typical output wiring diagrams. Figure 32 shows analog output wiring. Figure 33a through 33g show the standard frequency output and wiring. If only one output board is used, signal return is not referenced to any point. The floating signal return can be referenced to the output device, chassis ground, or earth ground.

Note: CSA requires signal return be referenced to earth ground.

When both outputs are used, they share a common ground. However, this ground is not referenced to any point (except CSA installations). The ground may be referenced to either output device.
Additional information on wiring is contained in Sections 3.6 to 3.6.3.4.

Analog Example

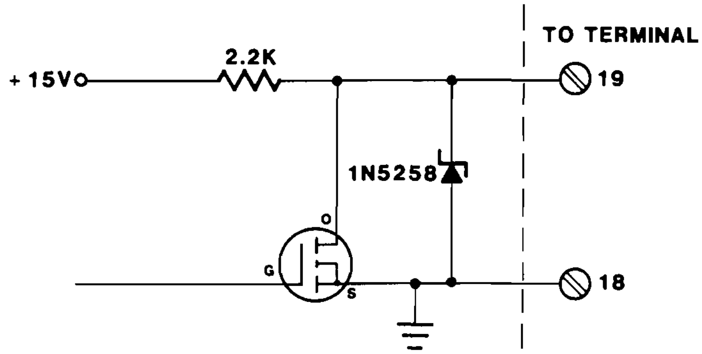
The analog output can be a voltage or milliamp output. In the voltage position a minimum input impedance of 100K is necessary. In the milliamp position the load cannot exceed 500 ohms. Figure 32 shows typical analog output wiring. Although shielded cable is recommended, it is not essential. However, twisted cable should be used.

The active 4-20 mA output signal may be used to operate one or more devices, such as Micro Motion's PI 4-20 process indicators. The total load, however, must not exceed 500 ohms.

Follow these steps, to connect two PI 4-20 process indicators to the analog output (Figure 32):

1. Connect signal output (terminal 17) of the flow meter electronics to the positive input of the first indicator.
2. Connect the negative output of the first indicator to the positive input of the second indicator.
3. Connect the negative output of the second indicator to the return terminal (16) of the flow meter remote electronics.

Figure 33a
Standard Frequency Output



Frequency Output

The standard frequency output from the Micro Motion mass flow meter (Figure 33a) is a common source FET circuit. It has a 15 V logic level. There is a 2.2K resistor in series with the +15 V (drain voltage). The drain voltage is the frequency output signal. A 36 V zener diode protects the frequency board circuit from spikes coming from external equipment.

To reduce the voltage level for TTL or other interfaces a resistor or zener diode must be inserted between the frequency output and return lines. When a resistor is used, the voltage drop across the load reduces the input signal to the attached device. When a zener diode is used, it shunts voltage over a certain level (for example, 4.7 V for TTL) before it reaches the attached device.

When wiring any external equipment to the Micro Motion mass flow meter output, shielded, twisted cable should be used.The shield should be connected to ground at terminal 12 of the mass flow meter electronics unit. If this is not possible, the shield should be connected to signal ground (terminal 13).

External equipment may determine the frequency range calibration.

Note: The frequency range calibration is the frequency output at the calibrated maximum full scale flow rate.

Devices such as a Red Lion Cub II (Example 2, Figure 33d) accept a maximum input frequency of 5000 Hz. Therefore, the frequency range calibration of a flow meter connected to a Cub II cannot exceed 5,000 Hz. Check the requirements of individual devices.

The flow meter frequency output must be compatible with the minimum on time and minimum off time requirements of the external equipment. Figure 33b is a square wave diagram showing the minimum on and off times. Table 10 in Section 5.4.2 gives the minimum times for different frequency range calibrations. Switches S4 and S5 on the frequency board (Figures 36 and 37) form a single binary divider switch. This switch divides the frequency output signal and increases the period. The setting of this switch determines the minimum on/off times of the frequency output.

Follow these steps to determine if the as-shipped calibration is compatible with the external equipment.

1. Check the input requirements of the external equipment. If the equipment only specifies a maximum pulses per time unit, the frequency range may be calibrated for any frequency below the specified maximum. However, if the equipment uses the period in an asymmetrical manner, minimum on/off times will be specified as well' and they must be taken into consideration.

Note: Be sure to use the same time units when comparing the frequency output to the external equipment input. Table 10 in Section 5.4.2 expresses the calibration in hertz (pulses/second) and the minimum time on/time off in milliseconds.

2. Compare the equipment requirements to Table 10 and check the frequency range calibration.

3. If the device accepts the calibration, no further steps are necessary. If not, recalibrate the frequency range according to Section 5.4.2.

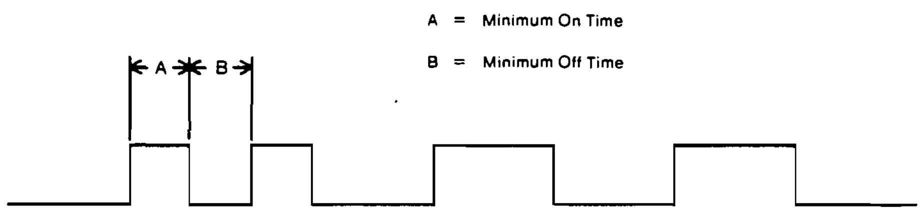
For example, the frequency range calibration can be compared to the requirements of a Kessler Ellis Totalizing Counter MK 14, 30 VDC, 25 c.p.s. (Example 1, Figure 33c).

According to step 1, the Kessler Ellis counter requires a minimum on time of 24ms and a minimum off time of 16ms (asymmetrical) at a maximum frequency of 25 hertz.

According to Table 10 in Section 5.4.2 (step 2) when the frequency range calibration is between 20 and 40 hertz, switch S4/S5 is set at 9 and the minimum on/minimum off time of the frequency output is 13 ms. This is insufficient time for the counter. Therefore, the frequency range must be calibrated for a maximum output frequency of 20 hertz or less. Switch S4/S5 must be set at 10 or higher to obtain a minimum on/off time of 26 ms or more.

Check the calibration according to step 3. If the meter must be recalibrated, refer to Section 5.4.2.

Figure 33b
Frequency Output
Wave Form



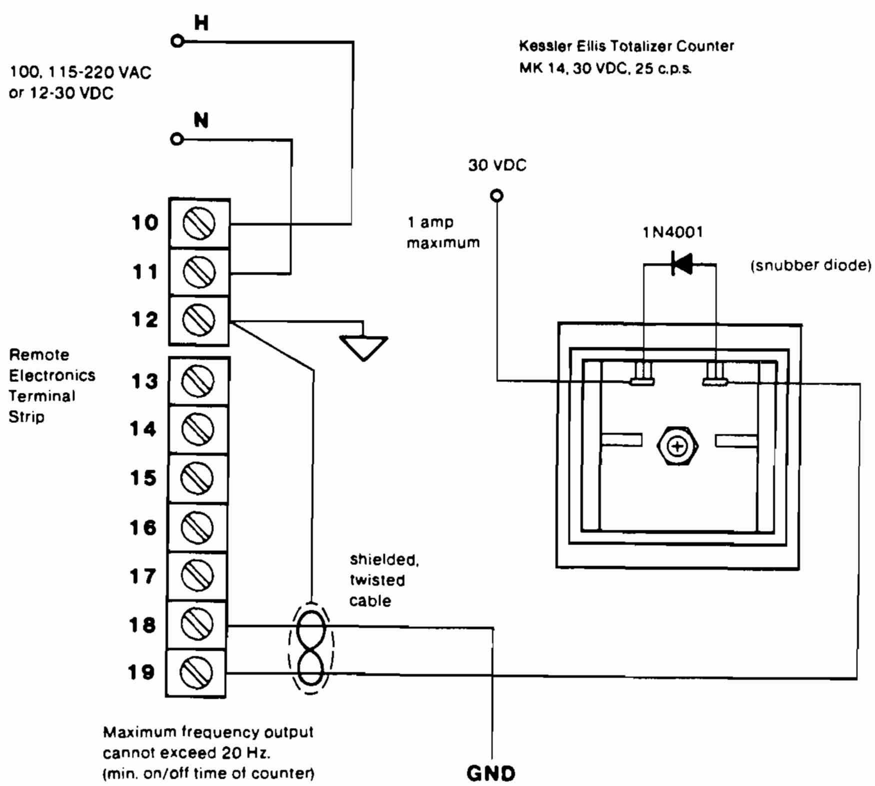
Frequency Example 1

The frequency output may be routed directly to a Kessler Ellis Totalizing Counter MK 14, 30 VDC, 25 c.p.s. The Kessler Ellis Counter accepts an input voltage of 30 VDC. The solid state circuitry on the frequency output board accepts a maximum of 30 VDC and has a sink capability of 1 amp. The frequency range calibration should be compatible with counter requirements. The preceding calibration guidelines use the Kessler Ellis Counter as an example.

Follow these steps to connect the flow meter frequency output to the counter. (Figure 33c):

1. Connect one terminal of the counter to the 30 VDC input voltage.
2. Connect a diode (1N4001) between the counter terminals. The cathode end should be connected to the same terminal as the input voltage.
3. Connect the output terminal (19) of the flow meter electronics unit to the other counter terminal (the anode end of the diode).
4. Connect the return terminal (18) of the flow meter electronics unit to ground.

Figure 33c
Frequency Output Wiring



Frequency Example 2

The frequency output may also be sent directly to a counter such as the Red Lion, Cub II. The output is the input drive signal for the Cub II. The Cub II uses 3.0 volt batteries. To avoid battery leakage or damage, the signal sent to the Cub II must be limited to 3.0 volts. The mass flow meter frequency output must be loaded with a resistor to limit the voltage level.

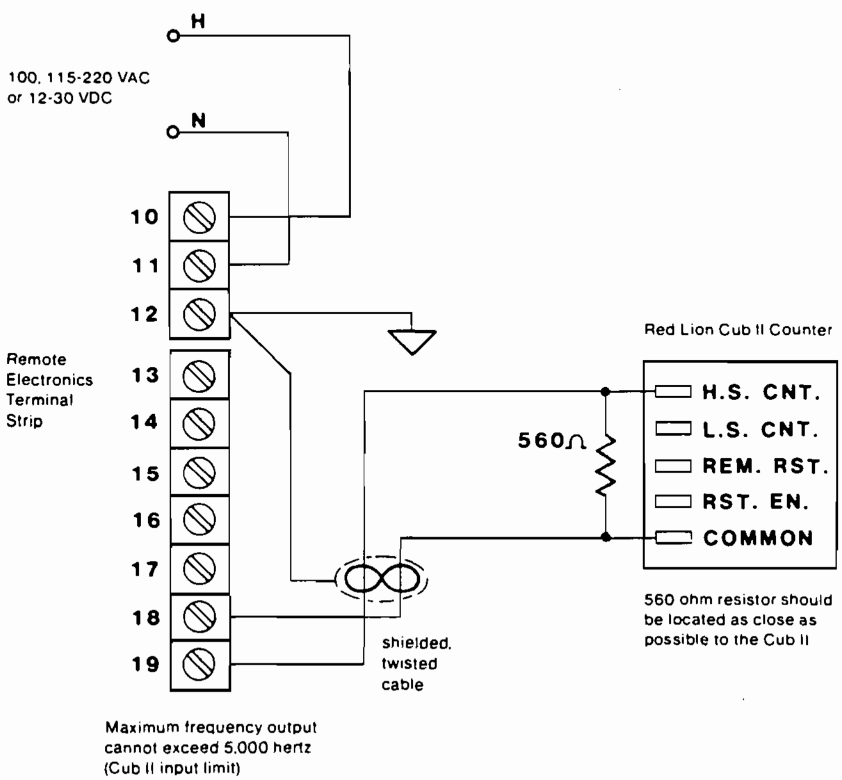
Follow these steps, to connect the frequency output from the mass flow meter to the Red Lion Cub II counter (Figure 33d):

1. The Cub II has a maximum input frequency limit of 5,000 Hz, the flow meter should be calibrated accordingly. According to Table 10 on Section 5.4.2, frequency range switches S4 and S5 must be set at position 2 or higher.

2. Connect terminal 19 from the flow meter electronics to the high speed count (H.S. CNT) input of the Cub II.

3. Insert a 560 ohm resistor between the output (terminal 19) and return (terminal 18) lines of the frequency output. To reduce noise, the load should be located as closely to the Cub II as possible.

Figure 33d
Frequency Output Wiring



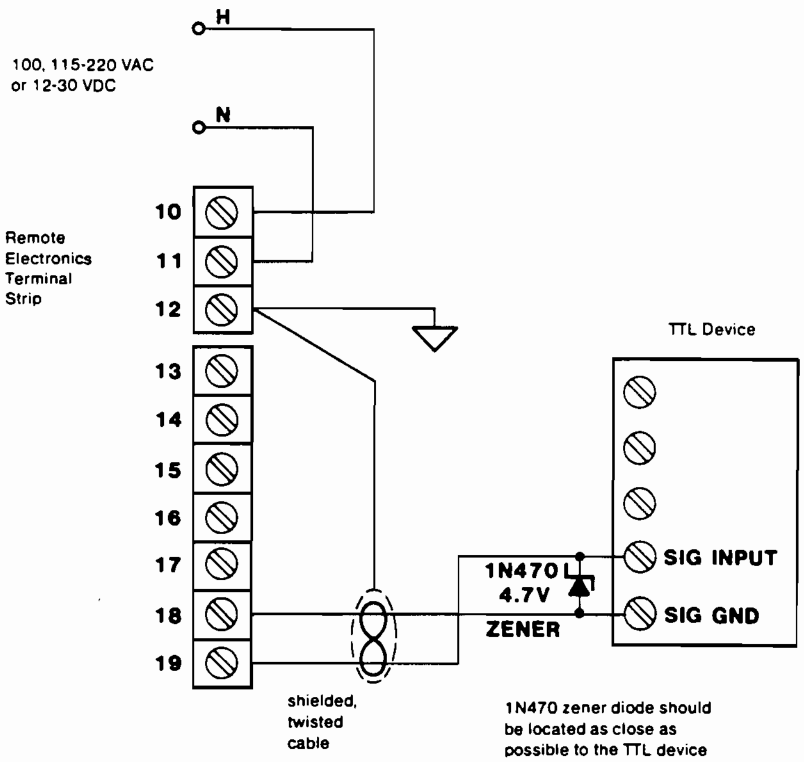
Frequency Example 3

The frequency output may be routed directly to a TTL device. The logic level for TTL cannot exceed 5 volts. Therefore, the excess voltage must be shunted.

Follow these steps, to connect the output to a TTL device (Figure 33e):

1. Connect terminal 19 to the signal input.
2. Connect terminal 18 to the signal return.
3. Connect a 4.7 V zener diode between the input and return lines as indicated in Figure 33e. The cathode end should be on the input line. When the 15 V signal exceeds the breakdown voltage of the diode, the excess voltage is shunted; thereby regulating the signal to 4.7 volts at the TTL device. Locate the zener diode as closely to the TTL device as possible to reduce noise.

Figure 33e
Frequency Output Wiring



Frequency Example 4

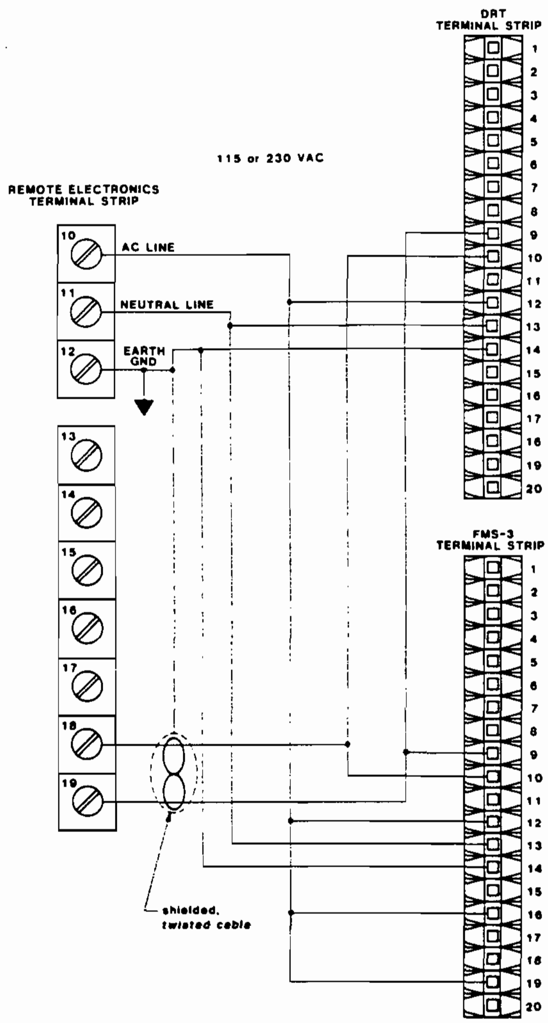
A single frequency output may be sent to multiple devices. However, both devices must be able to use the same frequency calibration.

Follow these steps, to connect the frequency output to Micro Motion's DRT digital indicator and FMS-3 Flow Monitoring System (Figure 33f):

1. Connect terminal 19 (signal output) on the flow meter electronics to terminal 6 (signal output) on the DRT and terminal 8 (signal input) on the FMS-3 Flow Monitoring System.

2. Connect terminal 18 (return) on the flow meter electronics to terminal 5 on the DRT and terminal 9 on the FMS-3 Flow Monitoring System.

Figure 33f
Frequency Output Wiring



*Note: When all units (meter and output devices) are connected to the same power supply, they must accept the same input voltage.

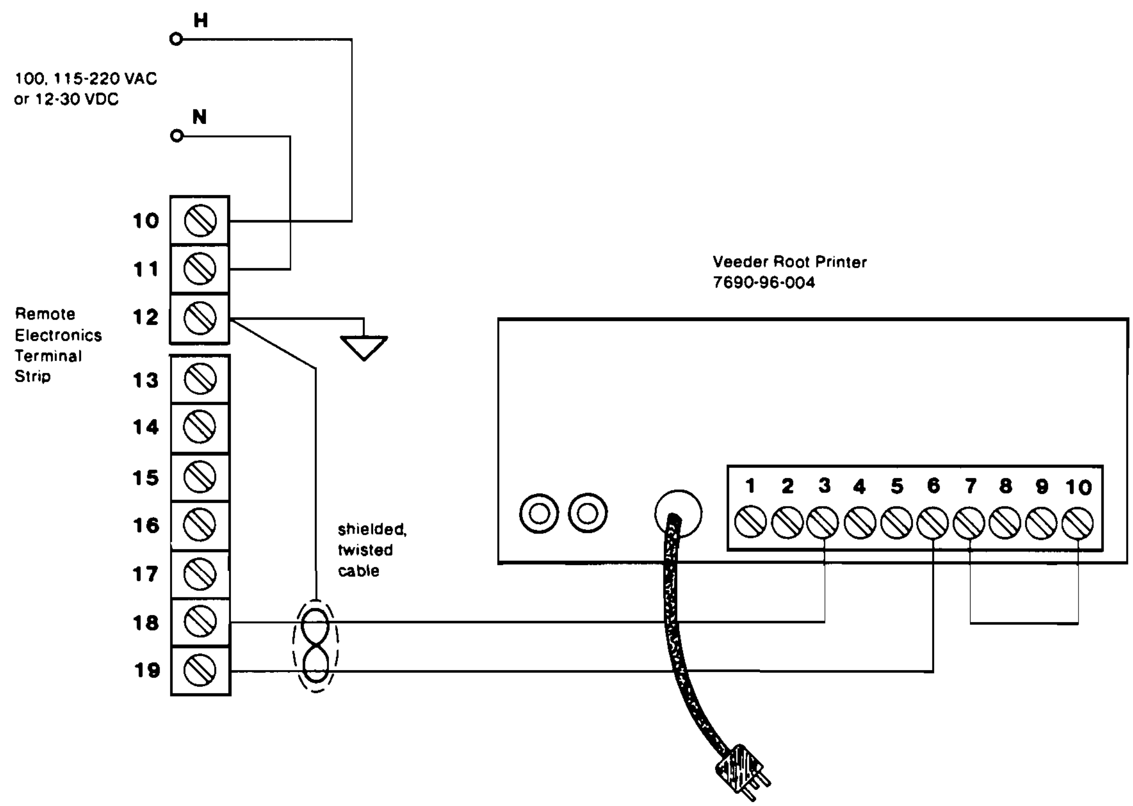
Frequency Example 5

The frequency output may be sent directly to the Veeder Root Printer.

Follow these steps, to connect the output to the Veeder Root printer model 7690-96-004 (Figure 33g):

1. The Veeder Root Printer accepts a maximum input frequency of 20 hertz. The flow meter output frequency cannot exceed 20 hertz. According to Table 10 in Section 5.4.2, switches S4 and S5 must be set at 10 or higher.
2. Connect the output terminal (19) of the flow meter electronics to terminal 6 of the printer.
3. Connect the return terminal (18) of the flow meter electronics to terminal 3 of the printer.
4. According to the Veeder Root manual, a jumper must be installed between terminals 7 and 10 on the printer.

Figure 33g
Frequency Output Wiring



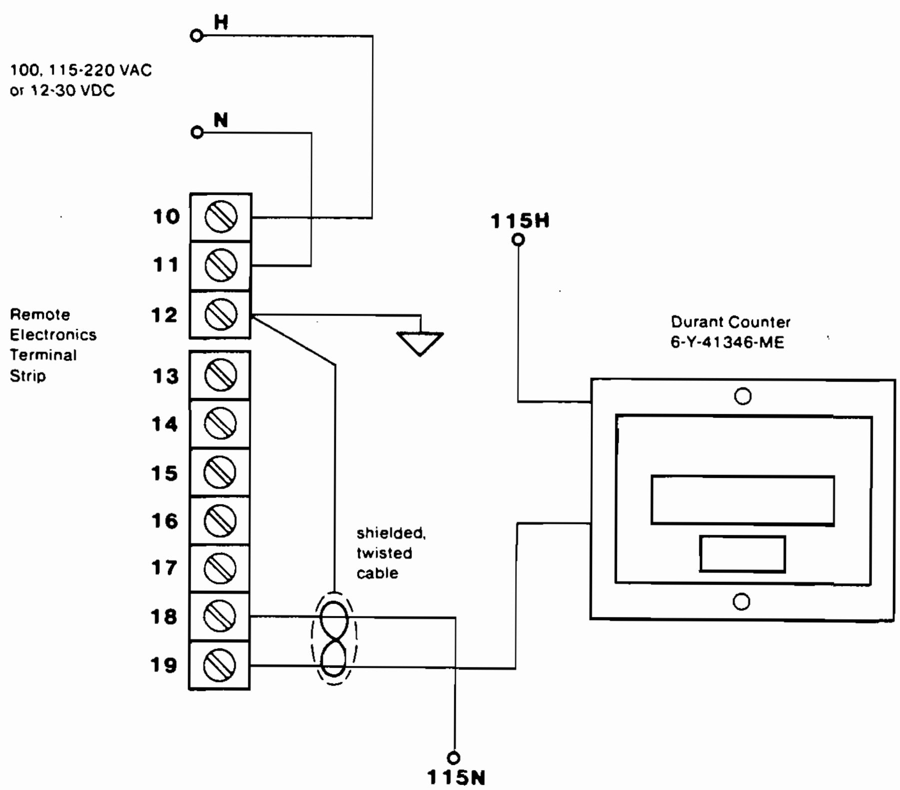
Frequency Example 6

Micro Motion offers an optional isolated frequency output. The isolated output circuit has a solid state contact relay rated to 250 V and 150 mA. Its main advantage is direct interface with higher voltage devices than the standard output. However, the flow meter frequency output is limited to 500 Hz.

Follow these steps, to connect the isolated output to a Durant 6-digit non-resettable 120 VAC electric counter (Model 6-Y-41346-406-ME).

1. The Durant counter accepts a maximum input of 1,000 cpm (counts per minute) with a minimum on time of 12 ms. The flow meter must be calibrated accordingly. 1,000 cpm converts to 16.67 pulses per second. The frequency output of the flow meter cannot exceed 16 hertz. According to Table 10 in Section 5.4.2, switches S4 and S5 must be set at 9 or higher to obtain a minimum on time greater than 12 ms. Also, the switches must be set at 10 or higher to obtain a frequency output less than 16 hertz. The switch setting must meet both requirements; the setting must be 10 or higher.
2. Connect the output terminal (19) of the flow meter electronics to the counter input.
3. Connect the return terminal (18) of the flow meter electronics to the 115 VAC neutral line.

Figure 33h
Frequency Output Wiring



*Note: An isolated frequency output is required with the 115 V counter. The maximum frequency output cannot exceed 500 Hz.

Appendix III

Appendix III contains schematic and assembly drawings of the printed circuit boards within the remote electronics unit. A brief paragraph, which identifies the field adjustable items and test points, accompanies each pair of drawings. The paragraph includes cross-references to the sections covering the adjustments. Descriptions of these items are covered in Sections 4.2 through 4.2.7. The signal processing which occurs on each board is covered in Section 2.4. Also, Figure 5 on page 11 shows the location of each circuit board. The terminal points are shown on each schematic. The location of pin 1 of each terminal socket is shown on the interconnection board assembly drawing.

Analog Board

The analog board (Figures 34 and 35) has three adjustable items. The analog output selection switch (S800) is labeled Output Select on the board. The volt/milliamp choices it provides are also labeled. Reset it according to Section 5.3.1.1. The analog board also has two potentiometers, the zero adjust (P801) and the range adjust (P800). Section 5.3.1.2 covers their use.

Figure 34
Analog Board
Assembly Drawing

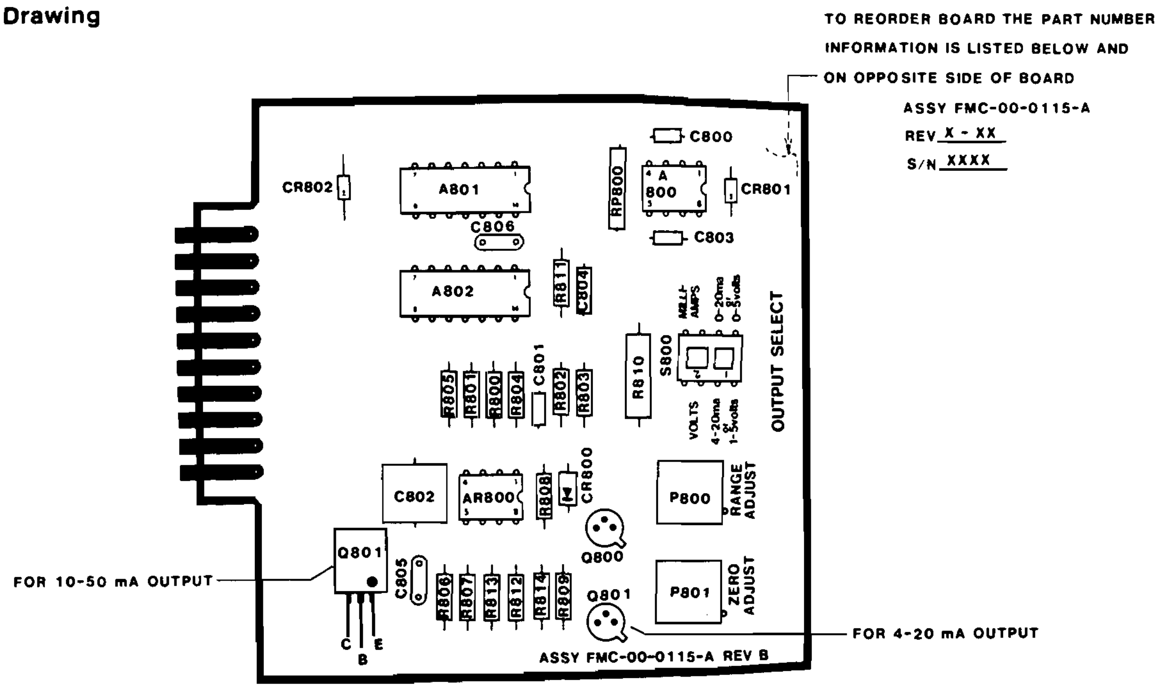
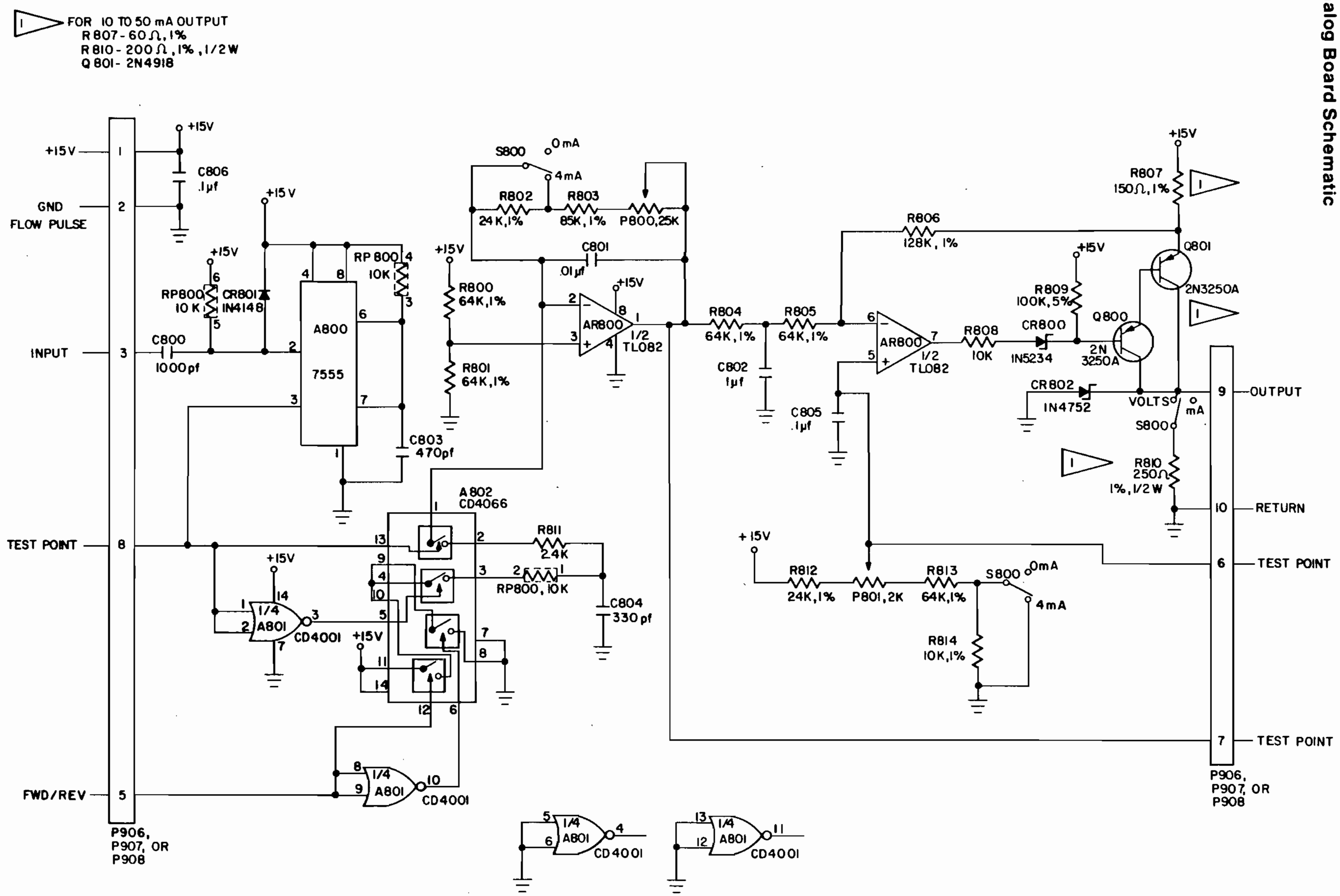


Figure 35
Analog Board Schematic



Frequency Board

The five frequency switches (S701-S705) are located on the frequency board (Figures 36 and 37). Section 5.4.2 covers frequency range adjustment and recalibration of these switches. To identify the the frequency range switches on the board:

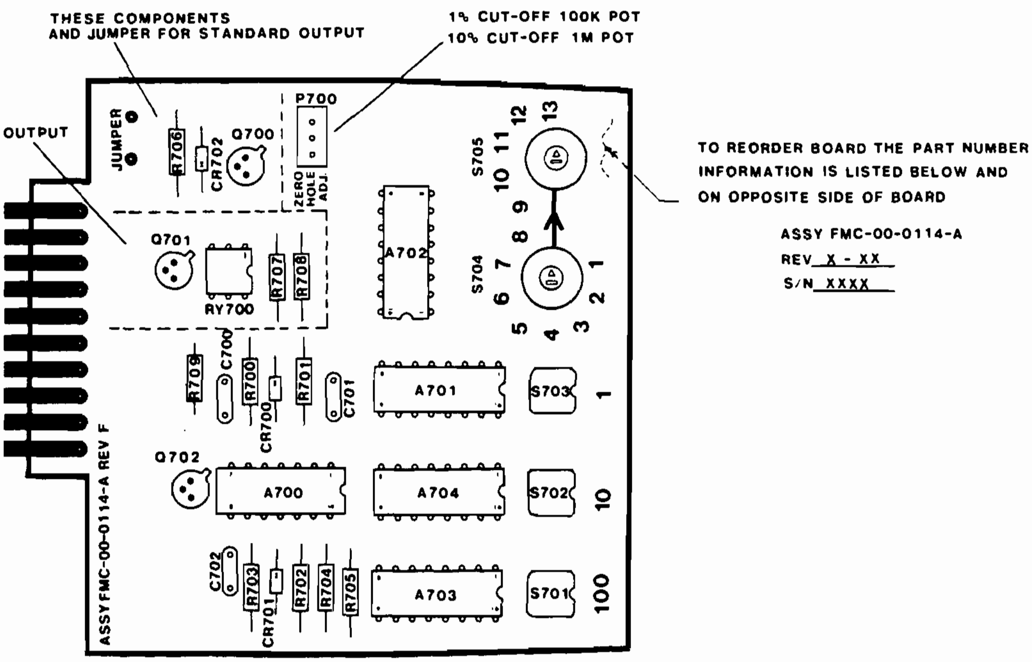
S701	=	S1
S702	=	S2
S703	=	S3
S704	=	S4
S705	=	S5

The calibration data label shows the factory setting of these switches.

Note: S4 and S5 together form a single rotary switch. If S4 is set between 1 and 8, the setting on S5 is not relevant. However, if the arrow in the center of S4 lines up with the arrow on the board, S5 is engaged. Then, the position of S5 between 9 and 13 determines the switch setting.

The frequency board also has a potentiometer (P700). This frequency cutoff potentiometer is labeled Zero Hole Adj., Section 5.3.2.2 covers its use.

Figure 36
Frequency Board
Assembly Drawing



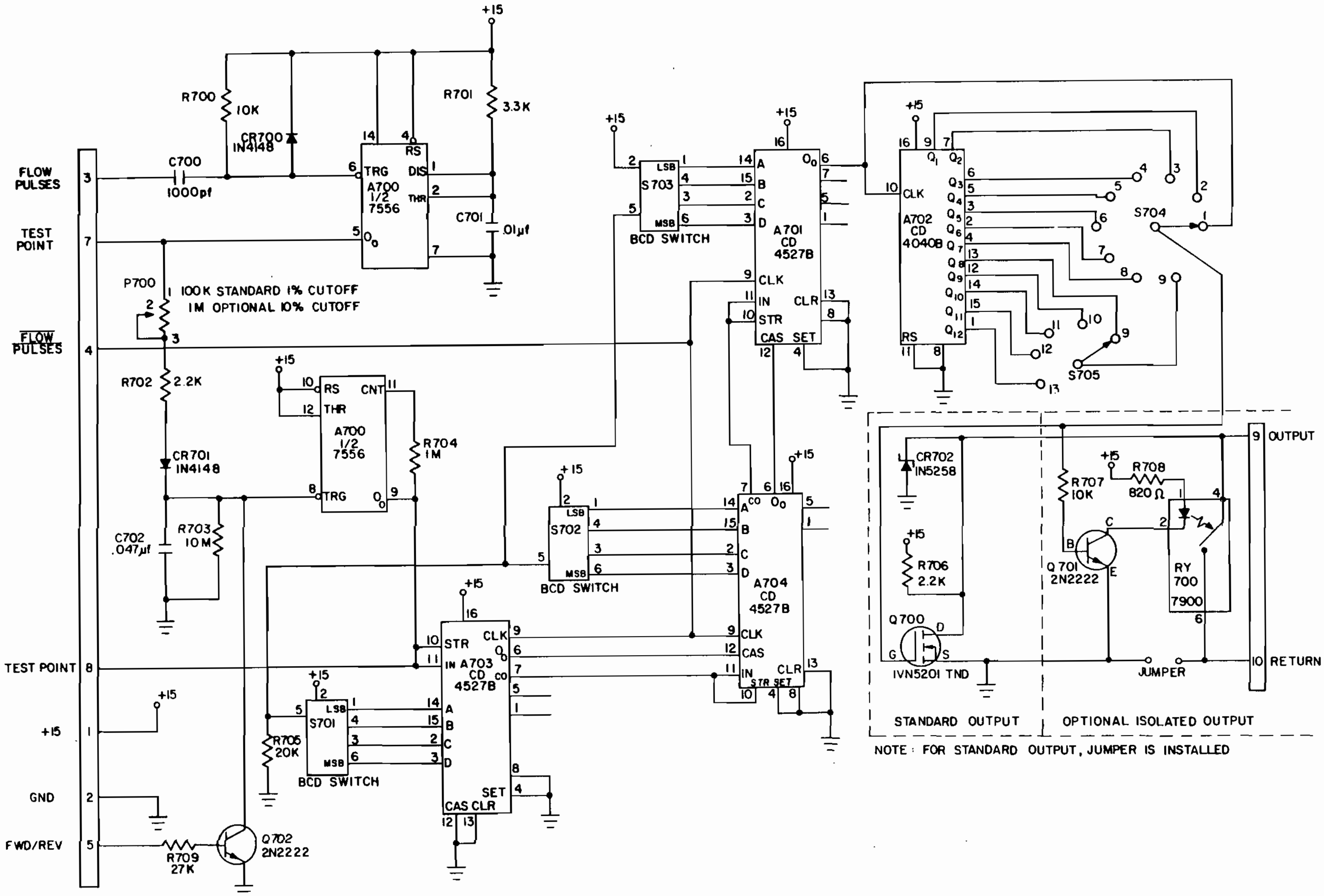
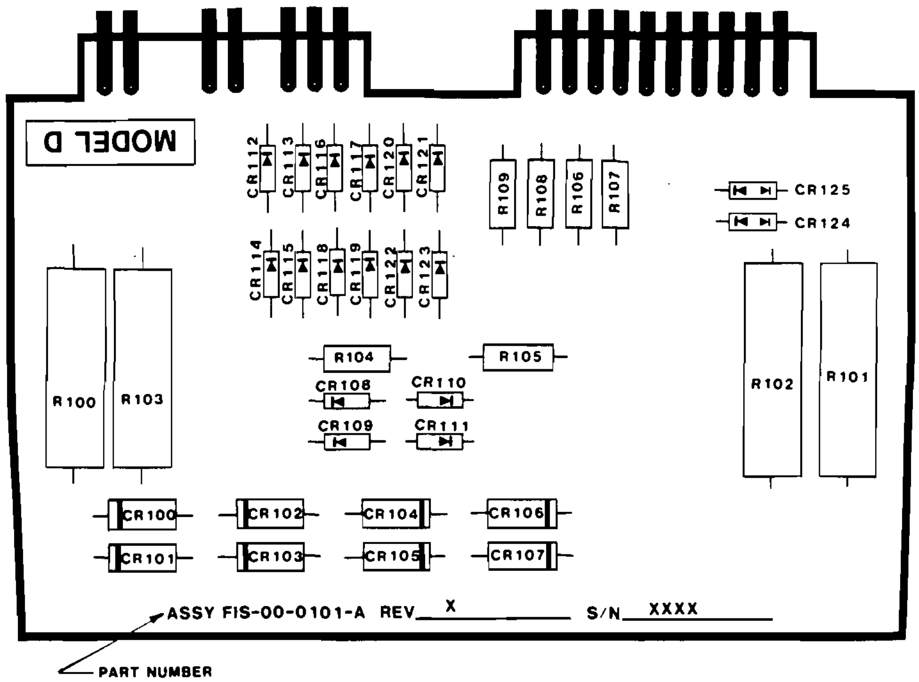


Figure 37
Frequency Board Schematic

Safety Board

The safety board (Figures 38 and 39) provides a barrier between the sensor and the electronics. It has no adjustable components.

Figure 38
Safety Board
Assembly Drawing



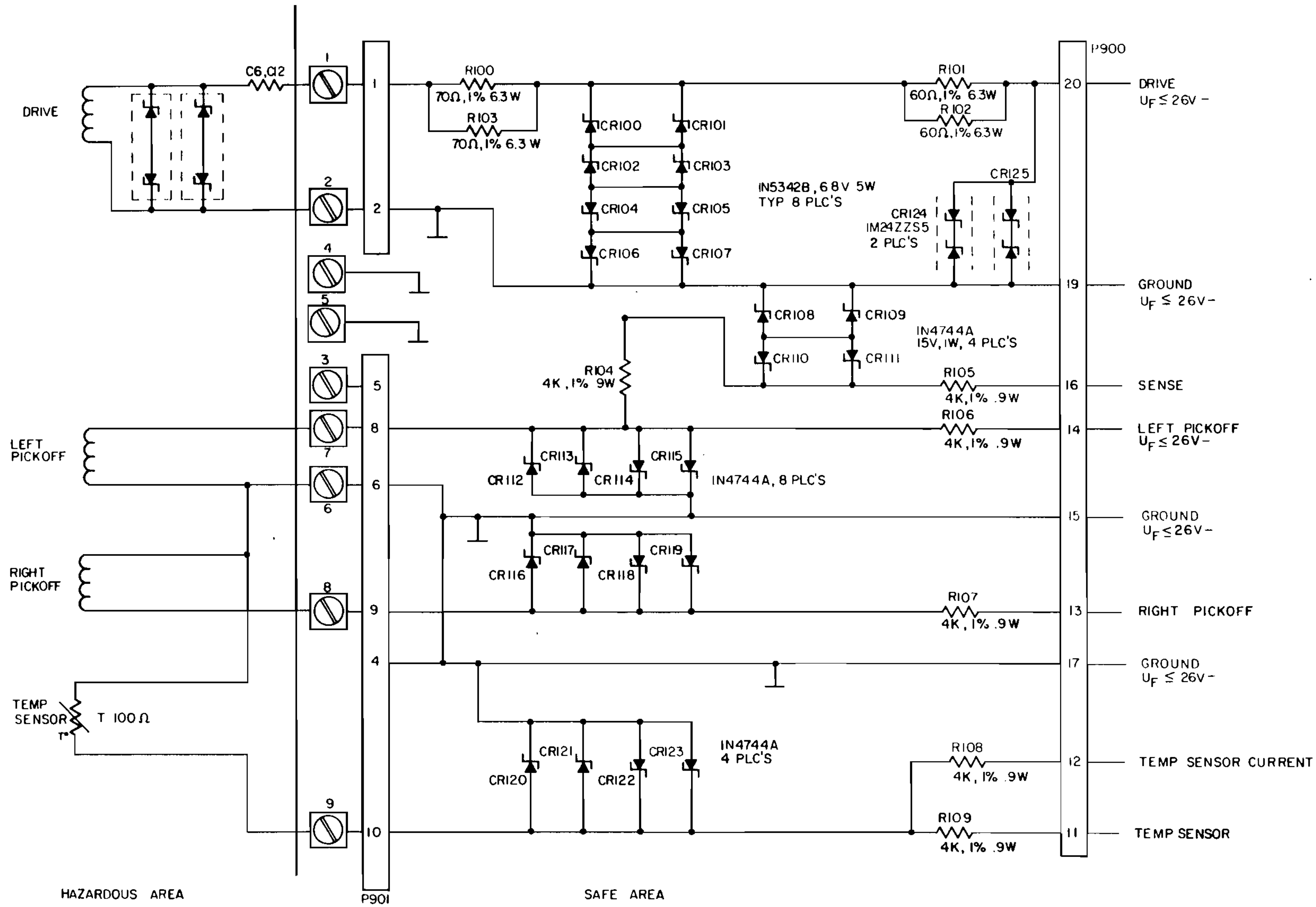
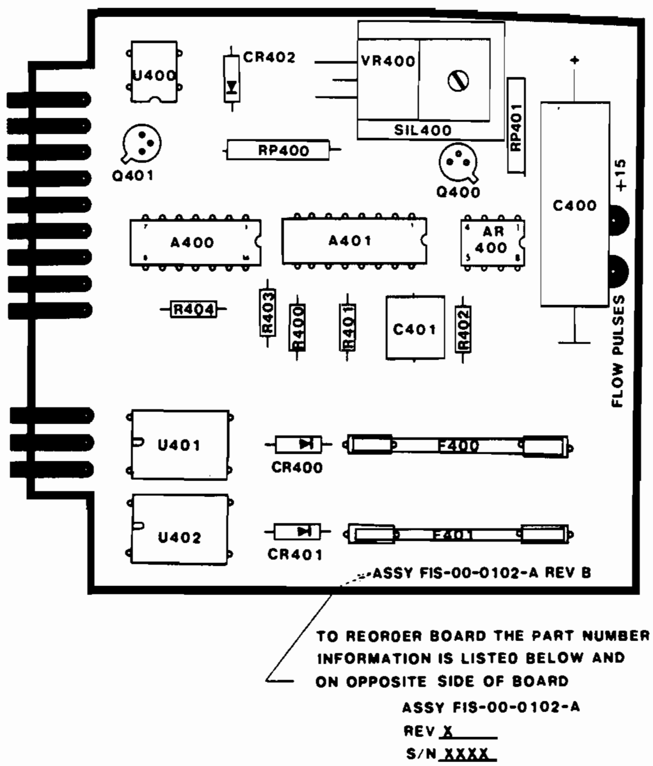


Figure 39
Safety Board Schematic

Isolation Board

The isolation board (Figures 40 and 41) has two test points, one for checking flow pulses, the other for checking the voltage level. Section 4.5.4, steps 8 and 9 cover troubleshooting procedures.

Figure 40
Isolation Board
Assembly Drawing



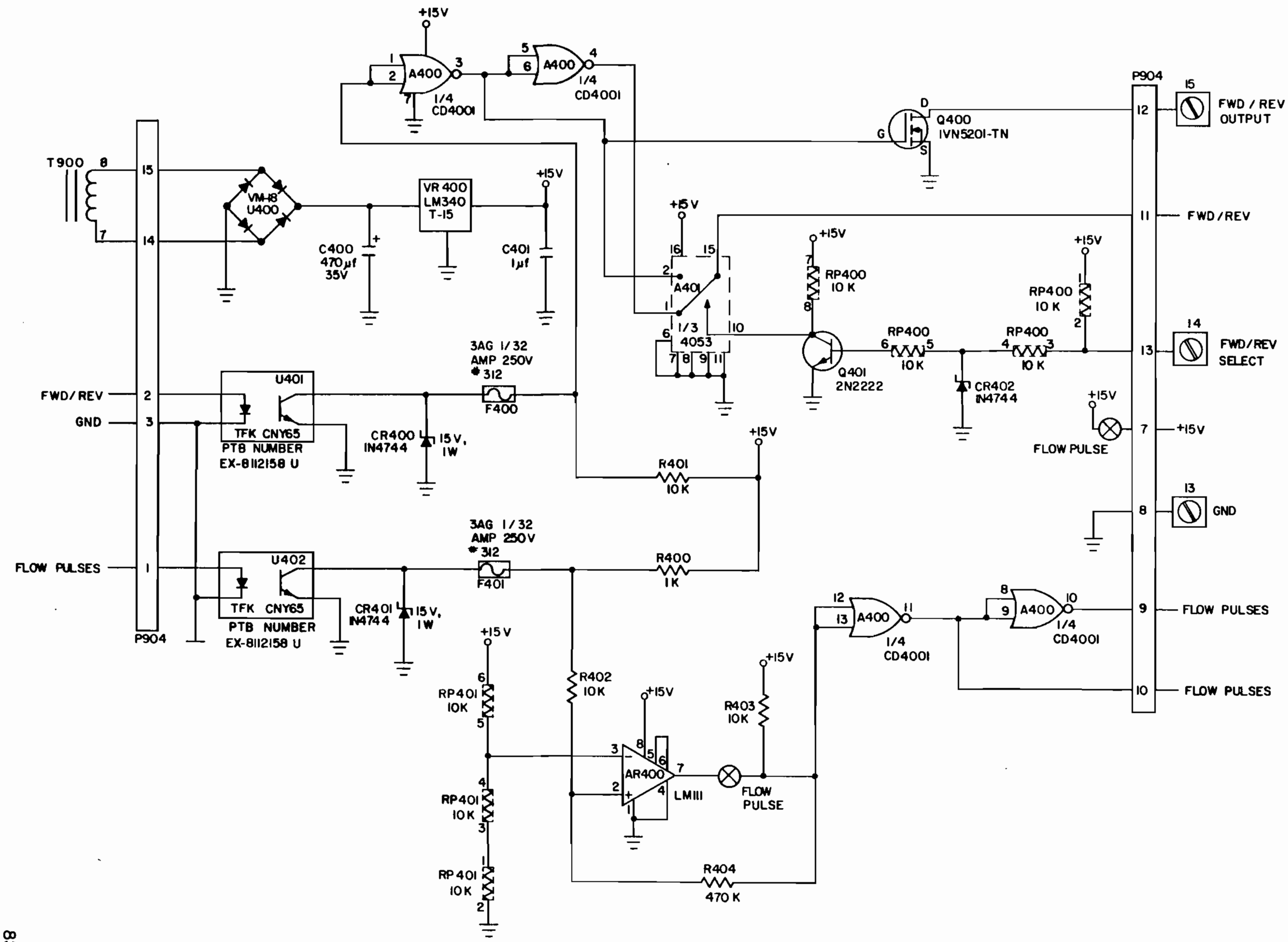
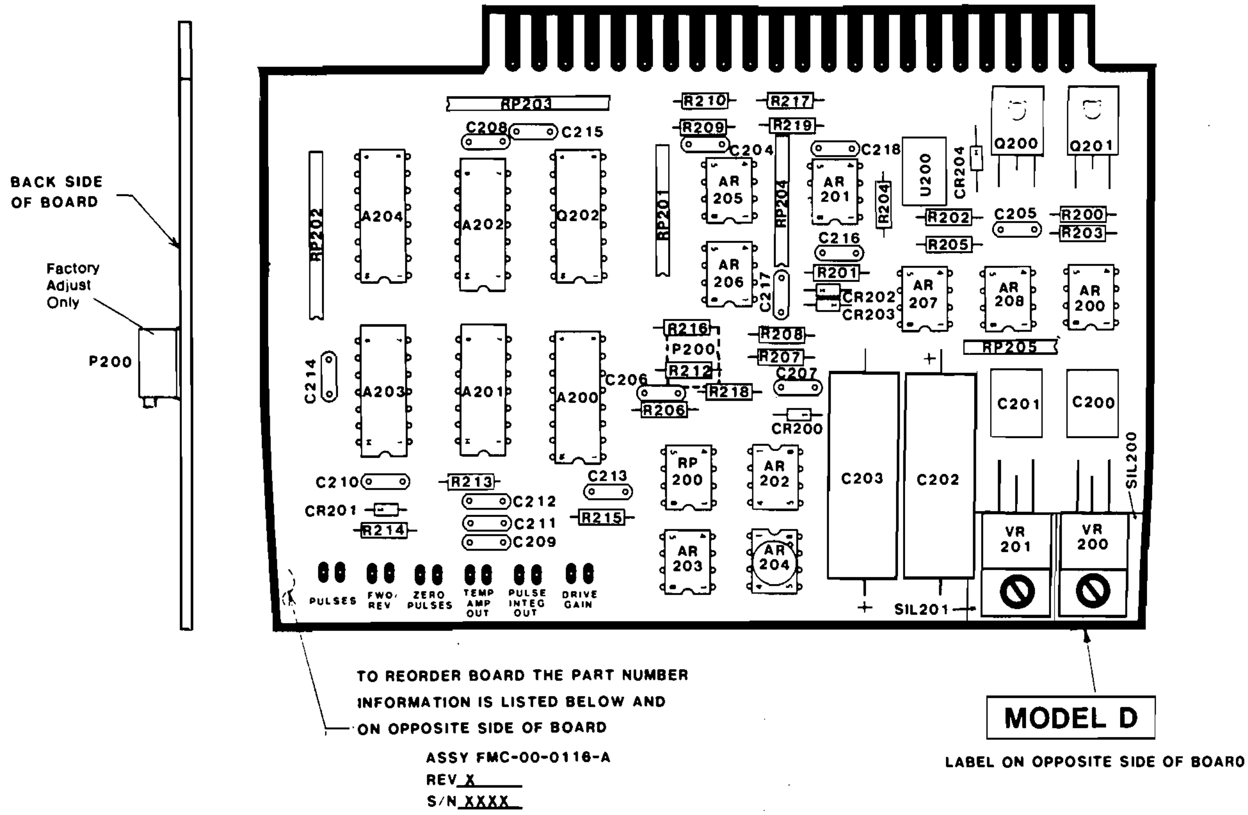


Figure 41
Isolation Board
Schematic

Figure 42
Drive Board
Assembly Drawing



Drive Board

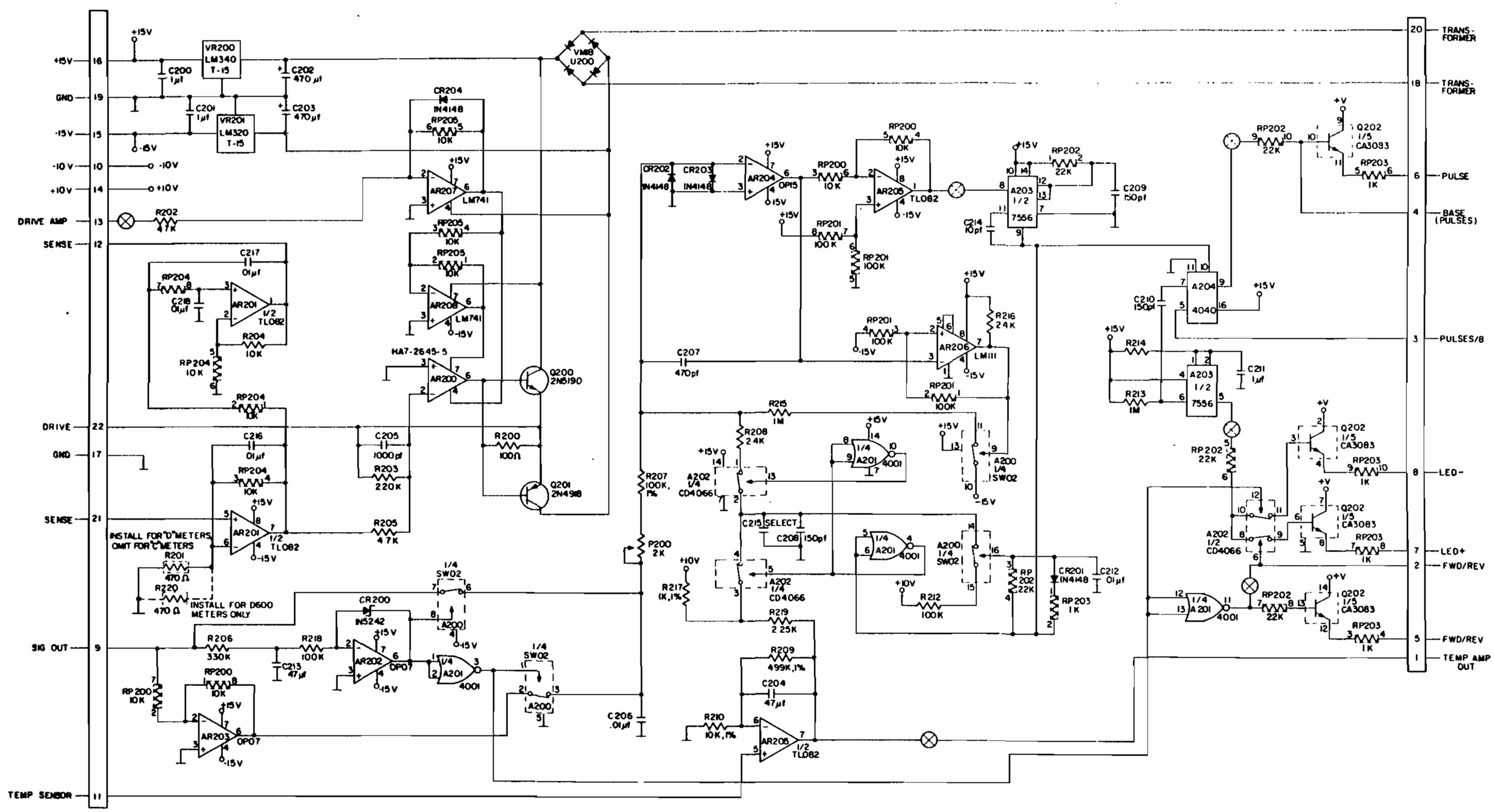
The drive board (Figures 42 and 43) has six test point wires. Table 15 describes them. Section 4.5.4, step 7 explains the procedure for checking signal continuity on the drive board.

Note: The D600 drive board contains different components than the standard Model D drive board. It is labeled D600 and is not interchangeable with other Model D drive boards.

Table 15
Drive Board Test Points

Test Point	Description
Pulses	A square wave 0 VDC to + 15 VDC. The frequency will vary according to flow rate. The frequency will be 0 with a no flow condition and ≅10,000 Hz at maximum flow rate.
Fwd/Rev	Either 0 VDC and green zero indicator light for forward flow or +15 VDC and a red zero indicator light for reverse flow.
Zero Pulses	(Internal use only.)
Temp Amp Out	The Temp Amp Out reading increases as the temperature of the sensor. Approximately 3.6 VDC when the process fluid is near room temperature. Increases to approximately 4.4 V at 125°F.
Pulses Intg Out	(Internal use only.)
Drive Gain	Range: +1.5 VDC to +9 VDC.

Figure 43
Drive Board
Schematic



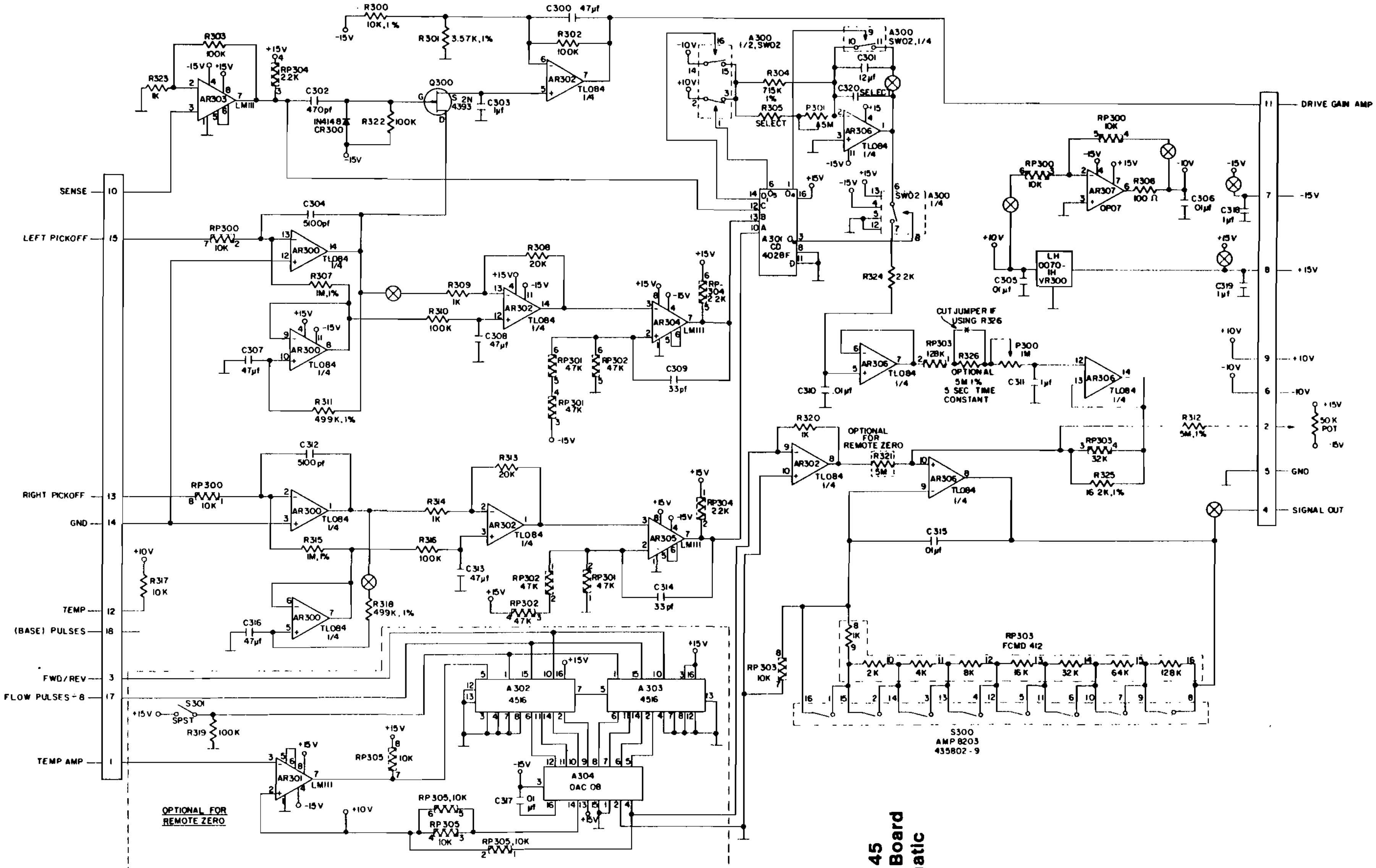
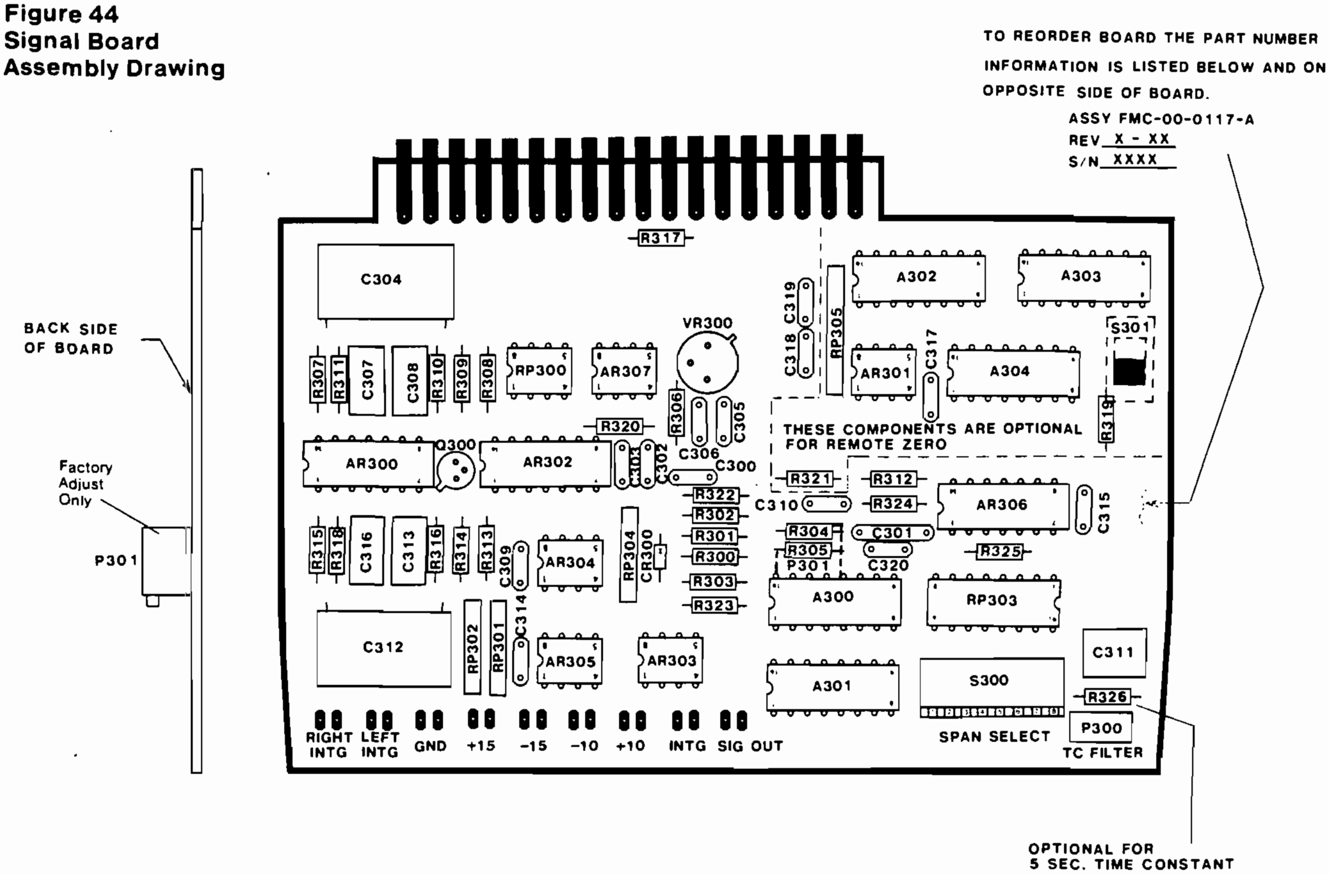


Figure 45
Signal Board
Schematic

Figure 44
Signal Board
Assembly Drawing



Signal Board

The user may adjust two factory preset items on the signal board (Figures 44 and 45). They are the span select switch (S300) labeled Span Select on the board, and the time constant adjustment potentiometer (P300) labeled TC Filter. Section 5.4.1 covers recalibration of the span select switch. Section 5.3.2.1 covers adjustment of the TC filter.

Table 16 describes the signal board test points. Section 4.5.4, step 6 explains how to check for signal continuity on the signal board.

Table 16
Signal Board Test Points

Test Point	Description
Left Intg	8 V p-p (2.8 RMS) and 40-150 Hz. The frequency depends upon the meter size and the process fluid.
Right Intg	Same as Left Intg, except 8 V p-p ±.5 VDC.
Gnd	Reference ground for the low voltage section of the remote electronics. Isolated from the output ground.
+15 V	+15 VDC ± 1V.
−15 V	−15 VDC ± 1V.
+10 V	+10 VDC ± 100 mV.
−10 V	−10 VDC ± 100 mV.
Intg	Square wave, base band 0 VDC at no flow, Amplitude −1.5 to −4 VDC. With flow, there will be a step on the positive going wave form.
Sig out	Range: approximately ± 3 VDC. 0 VDC at no flow, +3 VDC at maximum forward flow, −3 VDC and maximum reverse flow.

Interconnection Board

The interconnection board schematic shows the connections from terminal points on each board to the other boards and the output terminals. The assembly drawing shows where pin 1 of each board is located, when the board is in the socket.

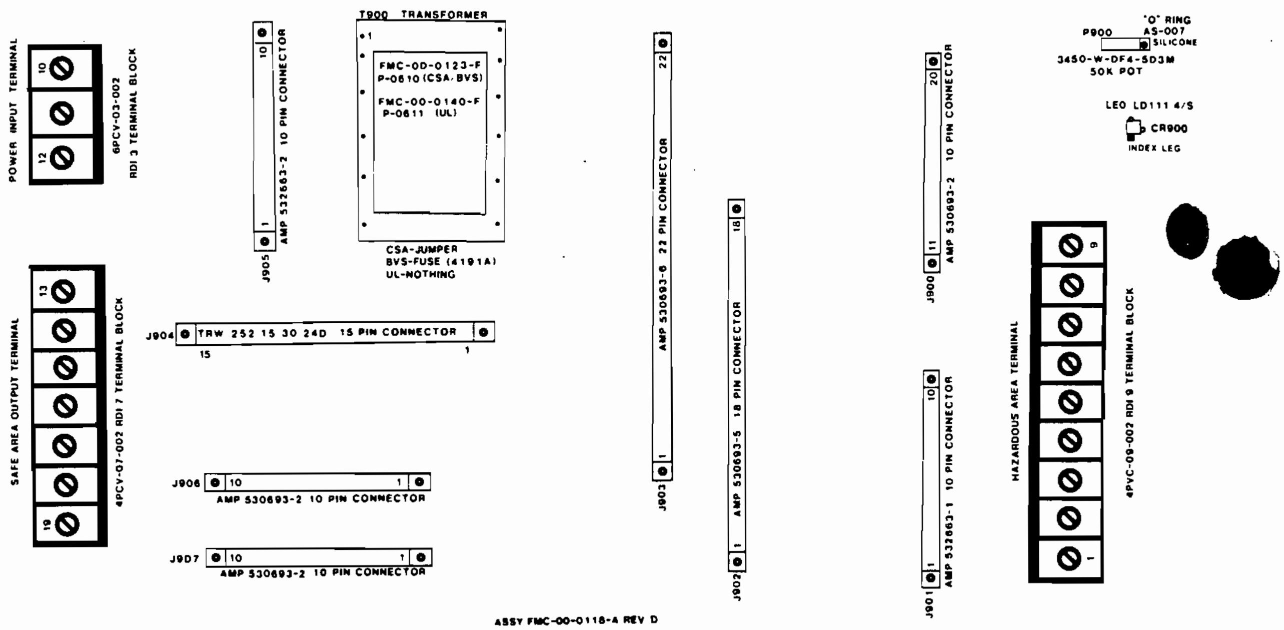


Figure 46
Interconnection Board
Assembly Drawing

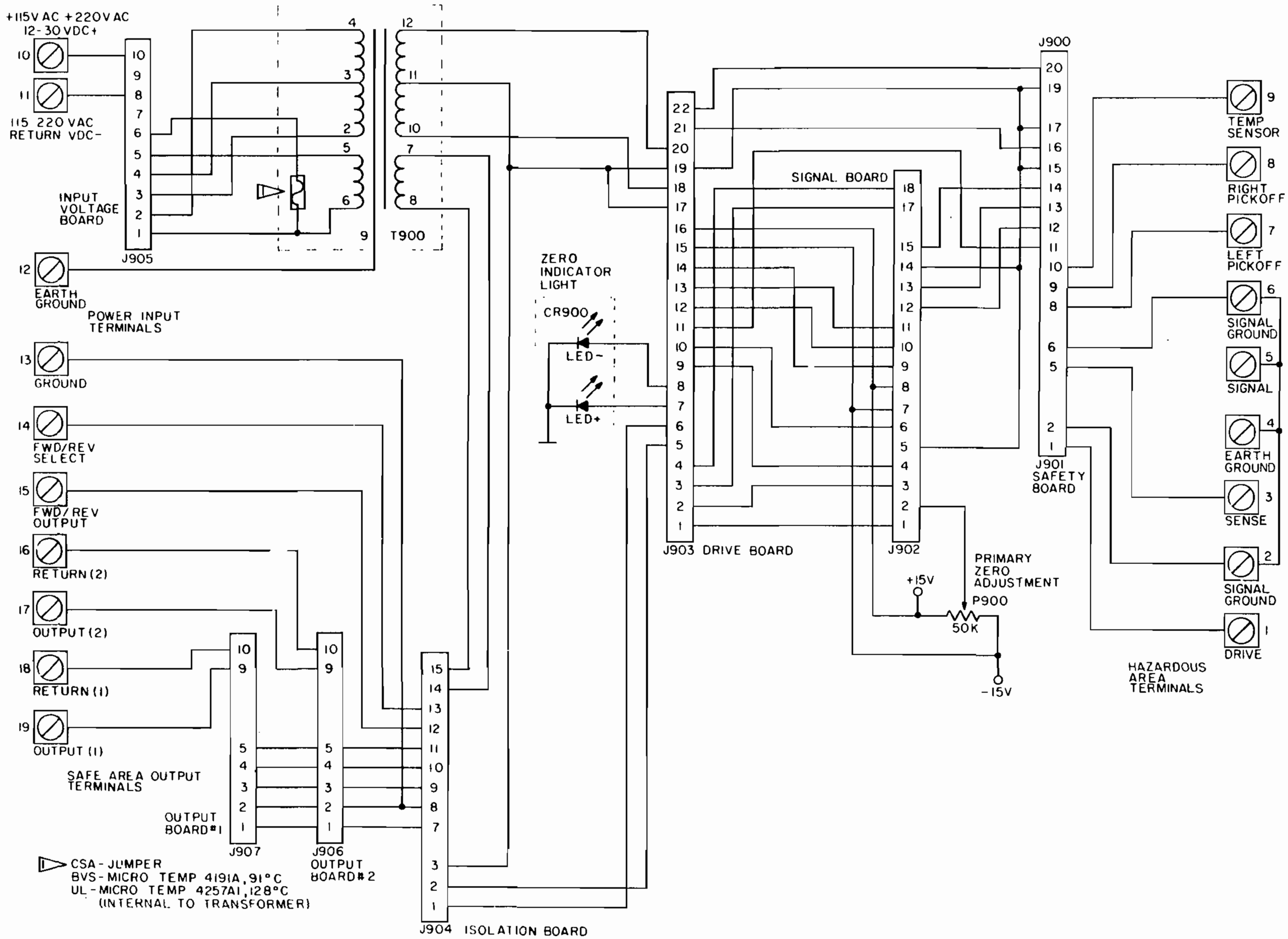


Figure 47
Interconnection Board
Schematic

Express Warranties

Micro Motion warrants its Products to be free from defects in material and workmanship under normal use and service for a period of one year from date of shipment from the factory. Micro Motion's obligation under this warranty shall be limited to repairing or replacing materials and or parts determined, by Micro Motion, to be defective in workmanship. Notice of warranty claims must be presented by the Buyer to Micro Motion no later than fourteen (14) days following the warranty's expiration date. Such notices must be directed to:

Micro Motion, Inc.
7070 Winchester Circle
Boulder, Colorado 80301
U.S.A.

Any defective Products must be returned to Micro Motion at the above address. If the defective Products are returned within ninety (90) days from the date of shipment from Micro Motion, transportation and insurance costs will be assumed by Micro Motion. After ninety (90) days, such costs will be the responsibility of the Buyer. All repaired and/ or replaced parts are warranted to be free from defects in material and workmanship under normal use and service, for a period of ninety (90) days from the date that the repaired or replaced goods are shipped from the factory, or until termination of the original warranty, whichever is longer.

This warranty does not apply to any Micro Motion Product which is determined to have been subjected to abuse, alteration, accident, or negligence in use, storage, transportation, or handling. Further, Micro Motion will not be liable for failure of parts which have been used in applications beyond the specifications in effect at the time of ordering of the Products. Furthermore, the flow sensor wetted parts are not covered by this warranty. Micro Motion is not liable for damage caused by erosion, corrosion, abrasion, or excesses of temperature or pressure. Items included in any purchase which are not manufactured by Micro Motion are covered only by the express warranties of the manufacturers thereof.

The foregoing warranties are to be held expressly in lieu of any verbal or implied guarantees or warranties, including those which apply to the merchantability, fitness, promptness of delivery of Products, or any other material obligations on the part of Micro Motion. In no event shall the Buyer be entitled to any consequential damages as defined in Section 2-715 of the Uniform Commercial Code. For goods sold as 'consumer goods,' 'personal injuries' shall be recoverable.

Micro Motion is not bound by any terms on the Buyer's order or specification sheets, which are at variance with Micro Motion's express warranties, invoices, or specification sheets which are current at the time of the order. Micro Motion's failure to object to such provisions shall not be deemed a waiver of any aforementioned warranties. This document constitutes the entire contract between Micro Motion and the Buyer with respect to warranties of Micro Motion's Products. No agent, employee, or representative of Micro Motion has the authority to supercede this document of Express Warranty.

These warranties apply to Products used in the United States and to Products exported by Micro Motion. Exporting of Products by other than Micro Motion or its designated Representatives will be cause to render the above warranties invalid unless such export is expressly underwritten by Micro Motion.

5

Document Number: 003145

Revision: "C"

INSTALLATION AND OPERATION MANUAL

FOR

MODEL LT81A AND LT87 MASS FLOWMETERS

NOTICE:

REVISION "C" ISSUE DATE: MAY 20, 1987

FOR TECHNICAL ASSISTANCE CALL: 1-800-854-1993

1755 La Costa Meadows Drive San Marcos, CA 92069 (619) 744-6950

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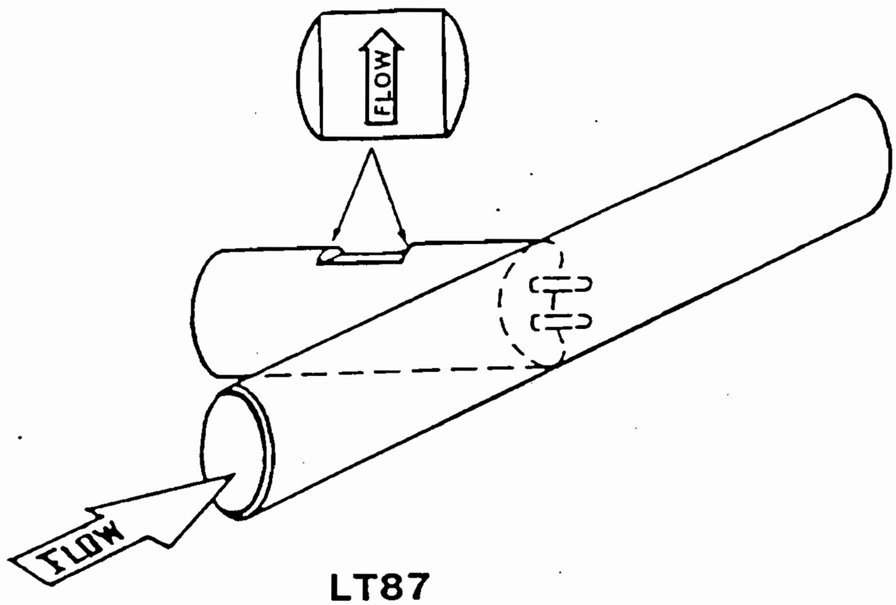
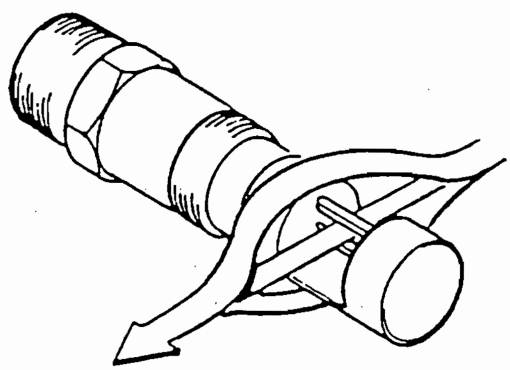


LT87



LT81A

FIGURE 1-1
Sensor Probe Assemblies

INTRODUCTION

GENERAL DESCRIPTION

The LT81A Mass Flowmeter will provide repeatable flow measurement over a flow range of 0.25 to 200 feet per second with a turn down ratio of up to 100:1 (under standard conditions). With the Dual Range Option, an LT81A turn down ratio can go as high as 1000:1 for applications requiring high resolution over a large flow range. (Standard Conditions for FCI are 70 degrees Fahrenheit and a pressure of one atmosphere.)

FCI has a new improved Mass Flowmeter for low flow rates that are usually difficult to measure, the LT87! No other instrument available can match the combined durability, reliability, and all around excellent performance of an LT87.

The LT87 is designed for easy in-line mounting in pipes and tubing sizes from 1/8 to 1 inch in diameter. With the optional 1/8" Injection Tube, an LT87 can accurately measure mass flow rates of air or gas down to 2 cc/second.

Under laboratory conditions, the LT87 has demonstrated an excellent repeatability of ± 1% over an 800:1 turn down ration. Because of this improved performance, the LT87 is available with an accuracy of ± 1% of full scale.

Like all FCI instruments, the LT81A and LT87 Sensor Probe Assemblies have no moving parts and feature rugged, all metal 316 Stainless Steel/Nickel Braze construction. The superior design of these instruments provides a level of reliability and durability that actually exceeds the requirements of most industrial applications. Each LT81A is pressure tested to 2000 PSIG; LT87s to 1250 PSIG. With optional High Temperature Sensors, the FCI Mass Flowmeters can provide reliable flow measurement at process temperatures from -50 to +850 Degrees Fahrenheit.

The Electronic Assembly for both the LT81A and LT87 Mass Flowmeters is housed in a NEMA 4 enclosure that can be located up to 500 feet away from the Sensor Probe Assembly. This feature is desirable when process conditions or convenience require separating the Electronic Assembly from the Sensor Probe Assembly.

Linear output signals are available in the standard 4-20 mA, or optional 10-50 mA, 0-10 Vdc, 0-5 Vdc, or 1-5 Vdc. A Flow Rate Indicator and/or Totalizer options are also available with a Liquid Crystal Display to indicate the present flow rate and/or the total amount of process media that has passed the Sensor Probe Assembly. The Rate and Totalizer Display options can be scaled in any unit that is proportional to the mass flow. Conversion to volumetric flow or flow velocity is also optionally available.

The Sensor Probe Assembly is composed of two pairs of thermowells. One thermowell in each pair houses a platinum Resistance Temperature Detector (RTD). The other half of one thermowell pair houses a heater which preferentially heats the adjacent RTD to provide the control element or "Active" sensor. The other RTD acts as a "Reference" sensor and is allowed to stabilize at the Process Medium Temperature. The second half of this thermowell pair provides mass equalization for the sensor thermowells.

This configuration creates a temperature differential between the two RTDs that is greatest at zero flow. Changes in flow rate directly and incrementally effect the heat dissipation and hence the temperature differential between the two sensors. This temperature differential between the active and reference sensors is essentially an exponential function of the mass flow rate.

Since the physical properties of different gases vary with temperature and pressure, the FCI Mass Flowmeters are factory calibrated using the actual gas, under conditions simulating the operating environment. For more detail about how the sensing element works, refer to the "Theory of Operation" section under REPAIR AND MAINTENANCE in this manual.

The Electronic Assembly provides power for the sensor probe, detects the temperature differential between the two RTDs, and amplifies and linearizes the sensor probe signal. The output signal can be calibrated to measure the flow rate as a function of velocity, actual or standard volume, or mass.

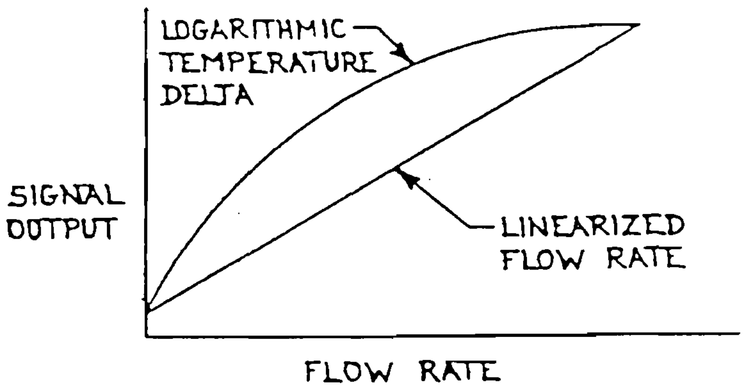


FIGURE 1-2
Output Versus Flow Rate

For example:

A flow rate can be expressed in ft/sec, standard cubic feet per minute (SCFM), or lb/hr. The standard flowmeter output signal is a linearized 4-20 mA current capable of driving a 1200 ohm load.

The standard flowmeter has numerous options available to meet your particular process requirements. An additional Temperature Compensation Calibration is available for those applications where the process temperature may span more than 30 degrees F.

One or two switch point relays may be ordered for process monitoring or control. The switch point relays may be field calibrated to activate at any flow rate within the calibrated flow range. A lower heater wattage is also available for heat sensitive media.

Proper selection from the available options will provide you with a Mass Flowmeter tailored to meet the conditions of your process gas. The functional options and some environmental options are described in more detail in the next section. Appendix "A" will assist you in determining which options were ordered on your present unit as well as help you when placing future orders.

FLOWMETER OPTIONS

The 12 digit part number for the Electronic Assembly will allow you to determine which options your instrument has installed. This number is on the main circuit board and your packing slip. The prefix is always 0017-. The remaining 8 alpha-numeric characters encode the options. Refer to Appendix "A" of this manual for assistance in decoding the options.

Option: Temperature Compensation.

Feature: Maintains calibrated accuracy when the process medium temperature spans more than 30 degrees F. The temperature differential between the two sensing RTDs is represented as a delta voltage in the electronics. The delta "V" signal produced by media flow can be offset by changes in the media temperature. This phenomena can produce a family of curves as shown in Figure 1-3. The temperature compensation option corrects for this non-linear shift to maintain an accurate measure of flow rate through the process media temperature range.

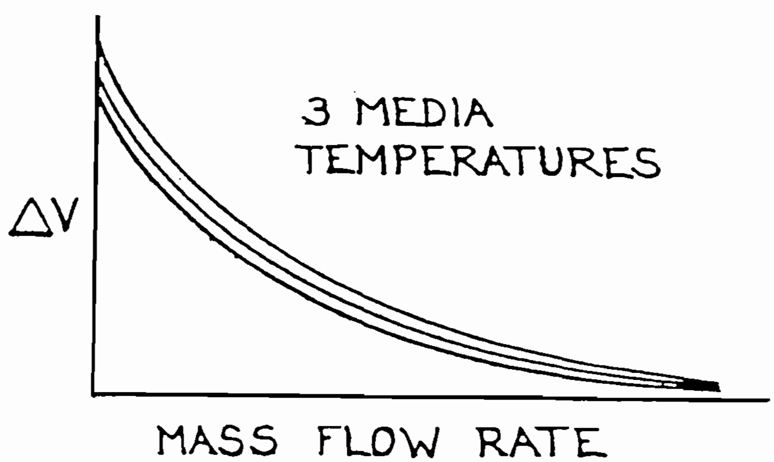


FIGURE 1-3
Effects of Media Temperature

Option: Switch Point Relay(s)

Feature: One or two field adjustable relays can be added to the mass flowmeter electronics. This option can provide a means of fail-safe alarms or interface with process control circuitry. Relay energization can be changed in the field by moving a plugable jumper on the circuit board. (See specifications for relay ratings.)

Option: Signal Output

Feature: Tailors the output signal to the process control requirements. The standard output signal is a 4-20 mA current loop; optionally available is a 10-50 mA current loop, 0-5 Vdc, 1-5 Vdc, or 0-10 Vdc analog output signal.

Option: Power Input

Feature: Standard Operating Power is 115 Vac with 230 Vac, 100 Vac, or 24 Vdc operating power optional.

Option: LCD Flow Indicator Display

Feature: Provides a local Liquid Crystal Display for the flow rate in units specified by the customer. The "Readout" can be calibrated as a function of velocity, standard volumetric flow, actual volumetric flow, or mass flow. The local display can be adjusted to display the flow rate in any units that are linearly proportional to the output signal. To prevent drift and displaying erroneous flow rates, the unit is disabled for flow rates out of the calibrated range.

Option: Totalizer

Feature: Sums the Total Media Flow over a specific period of time. For example, if your flow rate is measured in pounds per hour, then you could measure the total pounds which have passed the Sensor Probe Assembly from some initial start time. The eight digit Liquid Crystal Display is powered by a ten year life lithium battery so that the accumulated count is maintained during a power loss. The Totalizer is disabled below the low flow rate to prevent false counts under drift conditions.

Option: Mass to Volume Converter

Feature: The Mass to Volume Converter is a circuit board which when added to the LT81A Mass Flowmeter changes the output signal from a Mass Flow Signal to a Volume Signal. As the process medium temperature changes, the Mass to Volume Converter Board makes an adjustment to the linearized Mass Flow Signal to yield a velocity (F/S) or volume (ACFM) signal of the process medium flowing past the Sensor Probe Assembly.

Option: Rate Limit Board

Feature: The optional Rate Limit Board will allow you to adjust the rate of change of the output signal with respect to the input signal. An on-delay allows the sensors time to stabilize before the board becomes active. This option is used when the process media flow rate is erratic and a stable output signal is required.

ENVIRONMENTAL OPTIONS

The following options adapt the Mass Flowmeter to your process environment. If your process has special consideration not covered by these options, then please contact FCI at:

(619) 744-6950 or,

outside of California,

Toll Free at (800) 854-1993

Option: Mounting configuration

Feature: The LT81A can be ordered with the following process connections:

1. Either a 1" or 1½" MNPT.
2. Flange mount with minimum 1½", 150 lb.
3. Packing Gland mount for a retractable probe.

The LT87 can be ordered with the following in-line process connections:

1. 3/4" FNPT
2. 1" MNPT
3. Flange mount (Flange type customer specified)

Option: Special Coating

Feature: Protects the circuit board and components in moist environments. The circuit board is coated with an antifungus, waterproofing compound which protects the board from rust, moisture penetration, mold/fungus, and corrosive conditions.

Option: Explosion Proof Housing

Feature: Protects the electronics in a hazardous environment. The standard NEMA 4 enclosure is replaced with a NEC Class I & II, Div. 1 and 2 or a NEC Class I, Div. 1 and 2 enclosure.

Option: Epoxy Coated Housing

Feature: Provides moisture and corrosion protection for the Electronic Assembly Enclosure.

Option: Nuclear Qualification

Feature: The LT81A Mass Flowmeter has been qualified for nuclear applications in accordance with the requirements of IEEE Standards 323-1974, NUREG 0588, and 344-1975. For FCI Flowmeters being installed in Class 1E circuits within nuclear power generation stations, the

INTRODUCTION

FCI Qualification Test Report supercedes the subject Installation and Maintenance Manual in the areas of operating temperatures, required maintenance, and qualified Flowmeter options. An FCI Nuclear Application Specialist can assist specifying engineers in establishing environmental parameters and instrument configurations to ensure compliance with the latest Nuclear Regulatory Commission requirements.

SPECIAL CONSIDERATIONS

The FCI Engineering Staff is ready to help solve your process instrumenation problems. For example, FCI engineers developed a dual range flowmeter for applications requiring more accurate monitoring of the lower flow rates, while still providing large turndown ratios. This option provides the customer with two output signals from a single Sensor Probe Assembly. These two output signals share the lower flow rate limit. The additional output signal is adjusted to span only the lower part, say 10%, of the flow range; hence the output signal provides greater resolution of the lower flow rates allowing tighter process control in this critical area.

For monitoring flow through a large duct or stack where the flow varies over the cross-sectional-area, consult your FCI representative about our new "MT86" Multipoint Mass Flowmeter.

If your process has special considerations not covered by these options, please contact FCI at (619) 744-6950 or Toll Free at (800) 854-1993.

SPECIFICATIONS

Specifications apply to both the LT81A and LT87 unless otherwise indicated.

GENERAL

Application:

Air and gas flow measurement.
LT81A in ducts or pipes with minimum inside diameter of 1½".
LT87 in tubing or pipe from 1/8" to 1".

Process Connection:

LT81A available in
  1" or 1¼" MNPT;
  1½", 150 lb. minimum flange;
  Retractable probe assembly (packing gland).

LT87 available in
  3/4" FNPT;
  1" MNPT;
  Flange Mount (Flange type customer specified).

LT81A Insertion length:

standard U-dimension of 2 5/8" (67 mm);
special U-dimension of 1 5/8" (41 mm);
extended U-dimension available.
(U-dimension is from tip of probe to process connection, refer to the installation instructions)

LT87 Body length:

7.25" from start of thread inlet to outlet;
variations available only with flange connection.

Shipping Weight:

18 lbs. net.

SENSOR ASSEMBLY

Wetted Surfaces:

316 Stainless Steel with Nickel braze, per process specification AMS 4777.

Range:

LT81A: 0.25 to 200+ FPS (0.077 to 61 m/sec) in 14.7 PSIA air (range differs for other gases and higher pressure air).

LT87:

MODEL	AIR OR GAS (cc/sec)
LT87-4IT	2.0 - 200
LT87-4	20 - 20,000

Turndown ratio:

Select from 2:1 to 100:1, within the flow element range; Up to 800:1 with a dual range flowmeter.

Operating Temperature:

Standard -50 to +350 degree F. (-45 to +175 degree C.);
Special -50 to +850 degree F. (-45 to +445 degree C.).

Operation Pressure Ratings:

Sensor operating pressure up to 1250 PSIG (104 bar).

NOTE: Flow range available with either zero or non-zero base output. Customer to specify preferred arrangement.

SIGNAL OUTPUT

Drive Capability:

4-20 mA, max. load, 1200 ohms;
10-50 mA, max. load, 500 ohms;
0-5 Vdc, max. current, 2 mA;
1-5 Vdc, max. current, 2 mA;
0-10 Vdc, max. current, 2 mA.

Accuracy:

With standard calibration: +/- 1% of full scale or ± 3% of reading (whichever provides the best accuracy) at the temperature of calibration.
With Temperature Compensation Option: +/- 3% of full scale over a 120 degree F. (67 degree C.) process temperature range;
Special accuracies available.

Repeatability:

+/- 1% of full signal range at constant temperature and pressure.

EXTERNAL CONNECTION

Switch point relays:

single or dual DPDT for 2A at 115 Vac or 28 Vdc;
single or dual DPDT for 10A at 115 Vac or 28 Vdc.

Power Input:

115 Vac, 50/60 Hz, 15W (½ amp fuse recommended);
230 Vac, 50/60 Hz, 15W (¼ amp fuse recommended);
100 Vac, 50/60 Hz, 15W (½ amp fuse recommended);
24 Vdc, 12W (1 amp fuse recommended).

Remote Sensor Assembly Cable:

Maximum of 500 feet using 24 AWG, 8 conductor shielded wire; longer distances are possible using a heavier gauge wire for the heater circuit.

ELECTRONIC HOUSING

Enclosures:

NEMA 4; remote NEMA 4 and 7 enclosures available; explosion-proof enclosure complies with NEC Code, Class I, Groups C and D, Division 1 and 2; with NEC Code, Class II, Groups E, F and G, Division 1 and 2; with UL Standard 886 (Ref. Figures 2-4 and 2-5).

Connections: 1" FNPT (all models)

Temperature: 0 to +150 degree F. (-18 to +65 degree C.).

OPERATING INSTRUCTIONS

The LT81A and LT87 Mass Flowmeters require little interaction from the operator. Use of the standard output signal and optional switch point relay closures is application dependent. Operator action based on these functions must necessarily be specified by the process engineer.

The local display option provides a "Digital Readout" of the flow rate detected by the Sensor Probe Assembly. This display is set up to indicate only the calibrated flow rates. Hence, the display will indicate zero flow whenever the flow rate is below the lower-limit flow. Again, operator action based on observation of this display is application dependent and must be specified by the process engineer.

The Totalizer option provides a convenient method of accumulating some unit of flow. The unit accumulated and the action of the operator based on observation of this total is again application dependent. Operator action must be specified by the process engineer.

In some applications the operator may be required to reset the totalizer count. There is a two pin terminal strip located adjacent to the totalizer counter which will zero the totalizer display when it is shorted. FCI recommends that these two terminals be brought out along with the other electronic cabling and a reset switch installed for use by the operator. However, in those applications where this is not practical, the operator may turn off power and open the electrical enclosure to access the terminal strip directly. The zero reset may be done with the power off.

WARNING:

Turn off power before opening the electrical enclosure. Do not apply power with the enclosure open. Damage resulting from moisture penetration of the sensor or electrical assembly is not covered by the product warranty.

PHYSICAL DESCRIPTION

LT81A SENSOR PROBE ASSEMBLY

The LT81A Sensor Probe Assembly is constructed of 316 stainless steel with nickel braze. A matched pair of resistive temperature sensors, one active and one reference, is precisely located in their respective thermowells. These sensors are self-compensating for fluctuation in product temperature. The resulting shape is essentially cylindrical. As the diameter of the cylinder is 1.125", the minimum recommended clearance hole for mounting the sensor probe is 1.25" diameter.

The other critical dimension (U-dimension) is the distance from the tip of the probe to the leading edge of the mounting. It is necessary for the sensing elements to be positioned across the center line of the process pipe to ensure the calibrated accuracy.

To calculate the proper U-dimension for a flange mount, measure the distance, "D", from the center of your process pipe to the mating surface of the process flange. Add 1.0" to this distance to obtain the correct U-dimension. Refer to Figure 2-1.

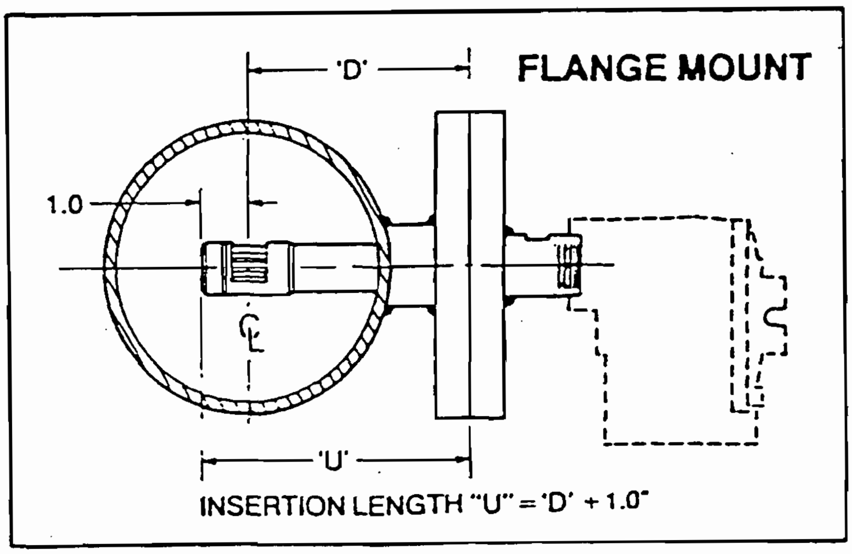


FIGURE 2-1
Flange Mount U-dimension

To calculate the proper U-dimension for an MNPT mount measure the distance, "D", from the center of your process pipe to the end of the mounting connector. Using a typical thread insertion length of 0.5", the U-dimension is calculated as "D" + 1.0 - 0.5 or simply "D" + 0.5". Refer to Figure 2-2.

The standard U-dimension for the LT81A is 2 5/8". Longer U-dimensions are available on request. It is possible to order an LT81A with a U-dimension of 1 5/8". Refer to the "Sensor Assembly Installation" section for suggestions on how to mount the LT81A in pipes with inside diameters less than two inches.

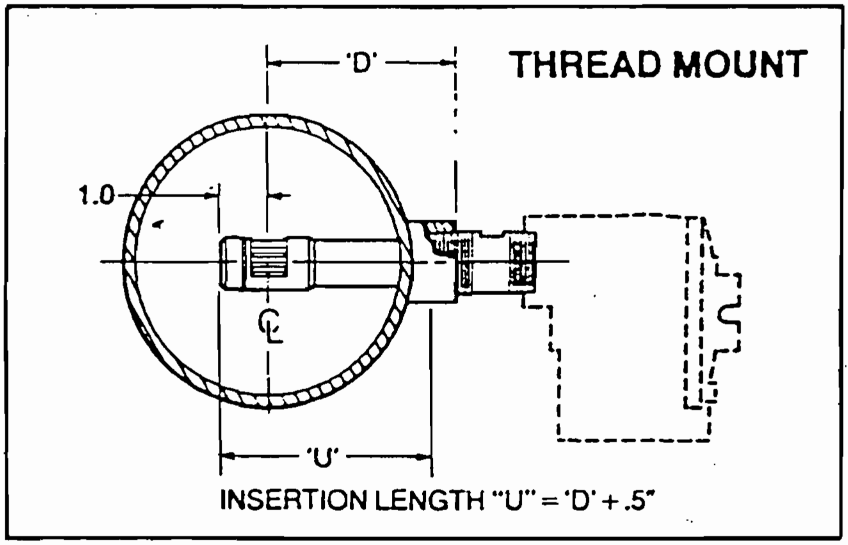


FIGURE 2-2
NPT Mount U-dimension

LT87 SENSOR PROBE ASSEMBLY

The LT87 Sensor Probe Assembly is designed for easy in-line installation in tubing or pipe from 1/8" to 1" in diameter. Process connections are available in 3/4" FNPT, 1" MNPT, or flange connection (flange type to be specifed by customer). Body length of the Sensor Probe Assembly from the start of thread inlet to outlet is 7.25 inches. All wetted surfaces are 316 Stainless Steel with Nickel Braze per process specification AMS 4777. Hastelloy C-276 with gold braze construction is optionally available. See Figure 2-3.

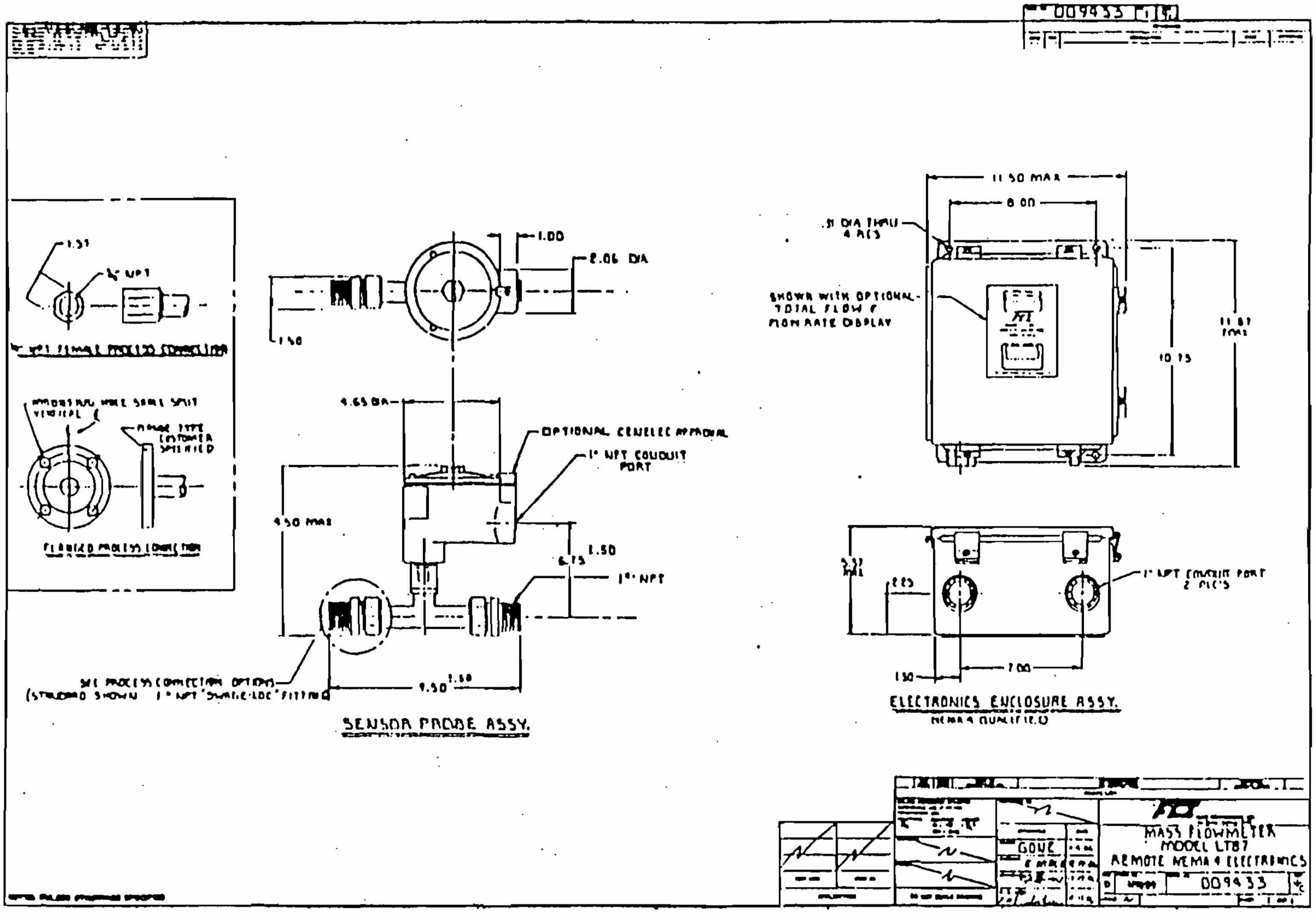


FIGURE 2-3
LT87 Mass Flowmeter

There are two LT87 models to choose from:

Model	Flow Range
LT87-4	20 to 20,000 cc/sec
LT87-4IT	2.0 to 200 cc/sec

NOTE: Calibrated flow-range is available in a non-zero based (standard) or zero based (optional) output.

ELECTRICAL HOUSING AND BOARD STACK

Your flowmeter options determine the type of electrical housing used and the way the circuit boards are stacked. The housings and circuit board configurations are identical for the LT81A and LT87. Figure 2-4 shows the possible housings for the standard flowmeter. Figure 2-5 shows the possible housings for the dual range flowmeter. To gain access to the electronics housed in the NEMA 4 type boxes, loosen the latch screws and swing the cover open. For the explosion proof housing, remove all the screws and remove the cover.

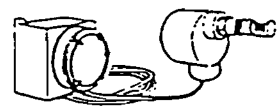
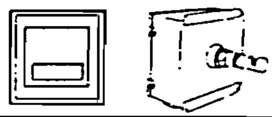
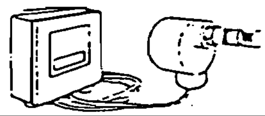
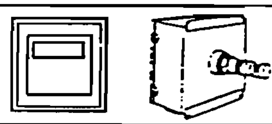
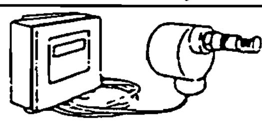
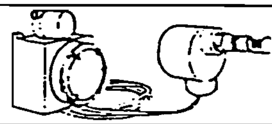
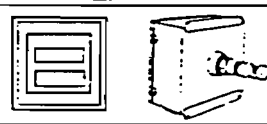
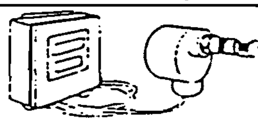
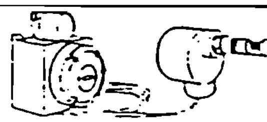
WARNING: Be sure to turn off the power before Opening the electrical housing. When the manual requires the use of electrical current, the operator assumes all responsibility for conformance to safety standards and practices.

Figures 2-6 through 2-9 can be used to correctly re-assemble the board stacks and the proper inter-connections for the various option configurations.

NOTE: Before attempting to remove or install a circuit board, please review the "Electrical Wiring Installation" section of this manual.

WARNING: Power must be off before removing or installing a circuit board.

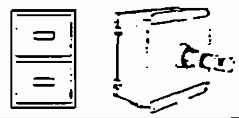
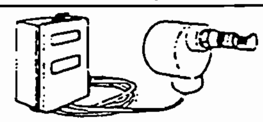
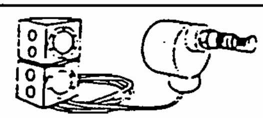
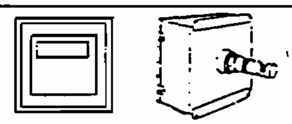
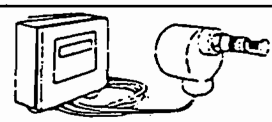
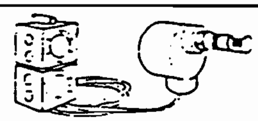
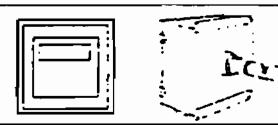
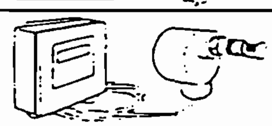
FLOWMETER ELECTRONICS HOUSING CONFIGURATIONS

Gen Box Options	Box Location	Box Type	Sales Code	Configuration Options	
NO DISPLAYS	INTEGRAL	NEMA-4	STN		10 x 10 Probe Enclosure
NO DISPLAYS	REMOTE	EXP.-PRF. PROBE / NEMA-4 ELEX.	R		4" Dia. Probe Enclosure 10 x 10 Remote Enclosure
NO DISPLAYS	REMOTE	BOTH EXP.-PRF.	RGCD		4" Dia. Probe Enclosure 8⅞ x 10½ Remote Enclosure
FLOW INDICATOR ONLY	INTEGRAL	NEMA-4	FI		10 x 10 Probe Enclosure
FLOW INDICATOR ONLY	REMOTE	EXP.-PRF. PROBE / NEMA-4 ELEX.	R FI		4" Dia. Probe Enclosure 10 x 10 Remote Enclosure
FLOW INDICATOR ONLY	REMOTE	BOTH EXP.-PRF.	RGCD FIGCD		4" Dia. Probe Enclosure 8⅞ x 10½ Remote Enclosure w/window
TOTALIZER ONLY	INTEGRAL	NEMA-4	TZ		10 x 10 Probe Enclosure
TOTALIZER ONLY	REMOTE	EXP.-PRF. PROBE / NEMA-4 ELEX.	R TZ		4" Dia. Probe Enclosure 10 x 10 Remote Enclosure
TOTALIZER ONLY	REMOTE	BOTH EXP.-PRF.	TZGCD RGCD		4" Dia. Probe Encl. 8⅞ x 10½ Remote Enclosure Attached 4" Totalizer Enclosure
FLOW INDICATOR & TOTALIZER	INTEGRAL	NEMA-4	FITZ		10 x 10 Probe Enclosure
FLOW INDICATOR & TOTALIZER	REMOTE	EXP.-PRF. PROBE / NEMA-4 ELEX.	R FITZ		4" Dia. Probe Enclosure 10 x 10 Remote Enclosure
FLOW INDICATOR & TOTALIZER	REMOTE	BOTH EXP.-PRF.	RGCD FITZGCD		4" Dia. Probe Enclosure 8⅞ x 10½ Remote Enclosure w/window

DOC NO 11071-A

FIGURE 2-4
Standard Flowmeter Electrical Housing

DUAL RANGE FLOWMETER ELECTRONICS AND HOUSING CONFIGURATIONS

Gen Box Options	Box Location	Box Type	Sales Code	Configuration Options	
NO DISPLAYS	INTEGRAL	NEMA-4	DR		10 x 10 Probe Enclosure
	REMOTE	EXP.-PRF. PROBE / NEMA-4 ELEX.	R DR		4" Dia. Probe Enclosure 10 x 10 Remote Enclosure
		BOTH EXP.-PRF.	DR RGCD		4" Dia. Probe Enclosure 8⅝ x 10⅞ Remote Enclosure
FLOW INDICATORS ONLY	INTEGRAL	NEMA-4	DRI		16 x 12 Probe Enclosure
	REMOTE	EXP.-PRF. PROBE / NEMA-4 ELEX.	R DRI FI		4" Dia. Probe Enclosure 16 x 12 Remote Enclosure
		BOTH EXP.-PRF.	DRI FIGCD RGCD		4" Dia. Probe Enclosure 8⅝ x 10⅞ (2 ea.) Remote Enclosure
HIGH RANGE TOTALIZER ONLY	INTEGRAL	NEMA-4	DRI TZ		16 x 12 Probe Enclosure
	REMOTE	EXP.-PRF. PROBE / NEMA-4 ELEX.	R DRI TZ		4" Dia. Probe Enclosure 16 x 12 Remote Enclosure
		BOTH EXP.-PRF.	DRI TZGCD RGCD		4" Dia. Probe Encl. 8⅝ x 10⅞ Remote (2 ea.) Enclosure Attached 4" Totalizer Enclosure
DUAL FLOW INDICATOR & TOTALIZER (HIGH RANGE)	INTEGRAL	NEMA-4	DRI FITZ		16 x 12 Probe Enclosure
	REMOTE	EXP.-PRF. PROBE / NEMA-4 ELEX.	R DRI FITZ		4" Dia. Probe Enclosure 16 x 12 Remote Enclosure
		BOTH EXP.-PRF.	FIGCD FITZGCD DRI RGCD		4" Dia. Probe Encl. 8⅝ x 10⅞ Remote (2 ea.) Enclosure Attached 4" Totalizer Enclosure

DOC. NO 11072-8

FIGURE 2 - 5
Dual Range Flowmeter Electrical Housing

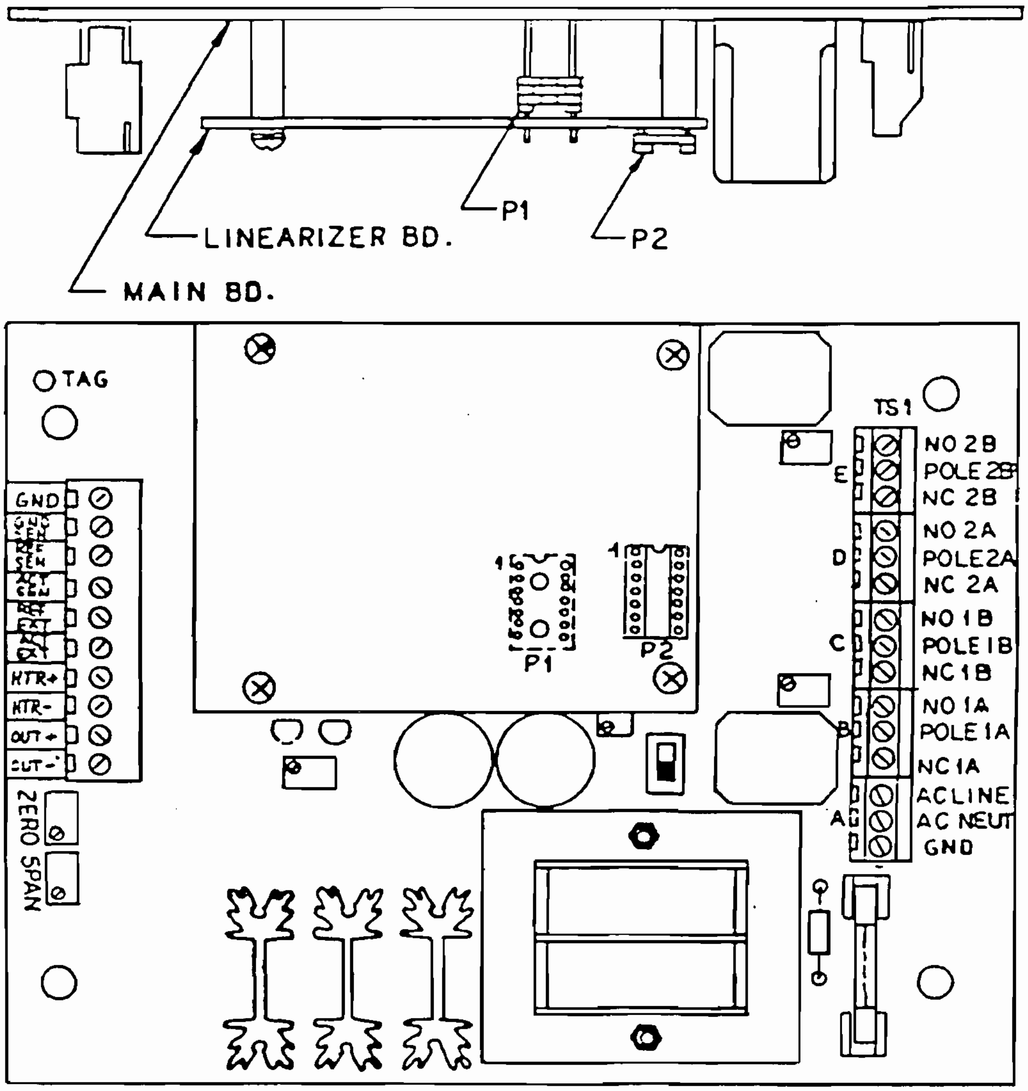


FIGURE 2-6
Standard Flowmeter Board Stack

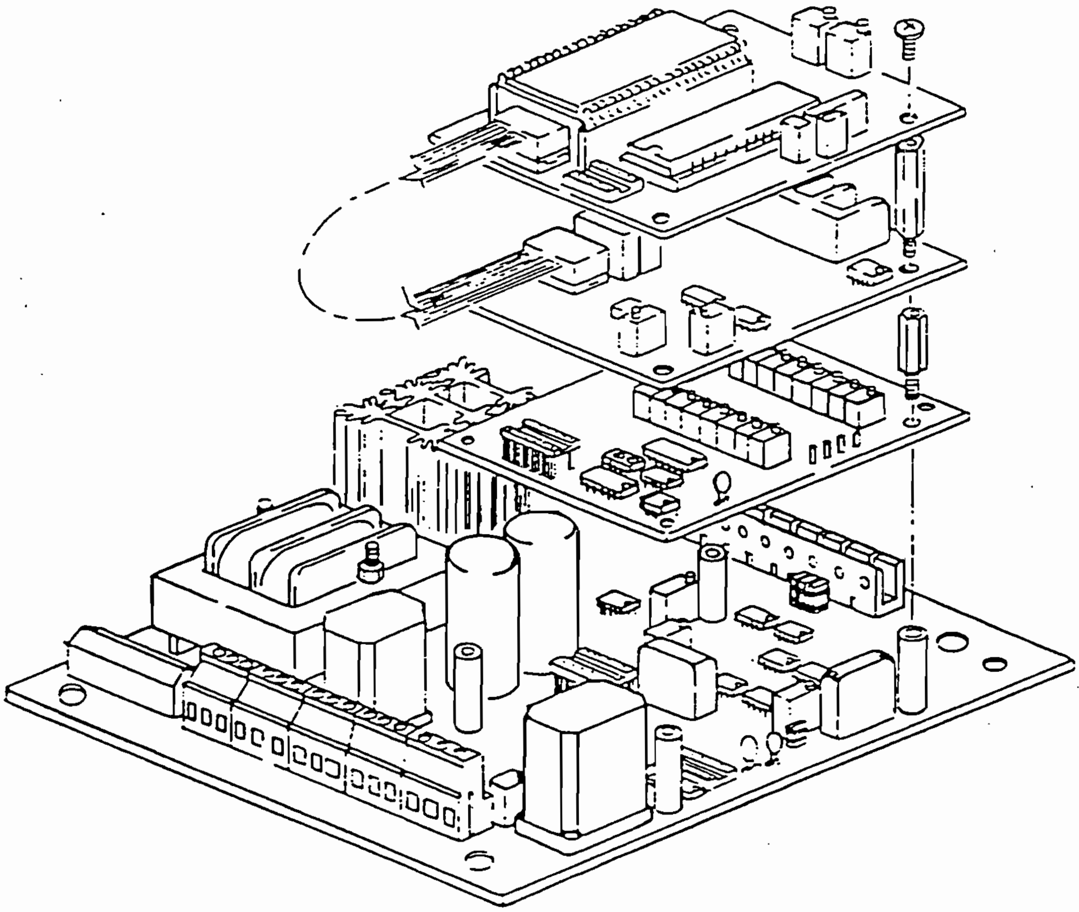


FIGURE 2-7
Flowmeter Board Stack with Display and Totalizer

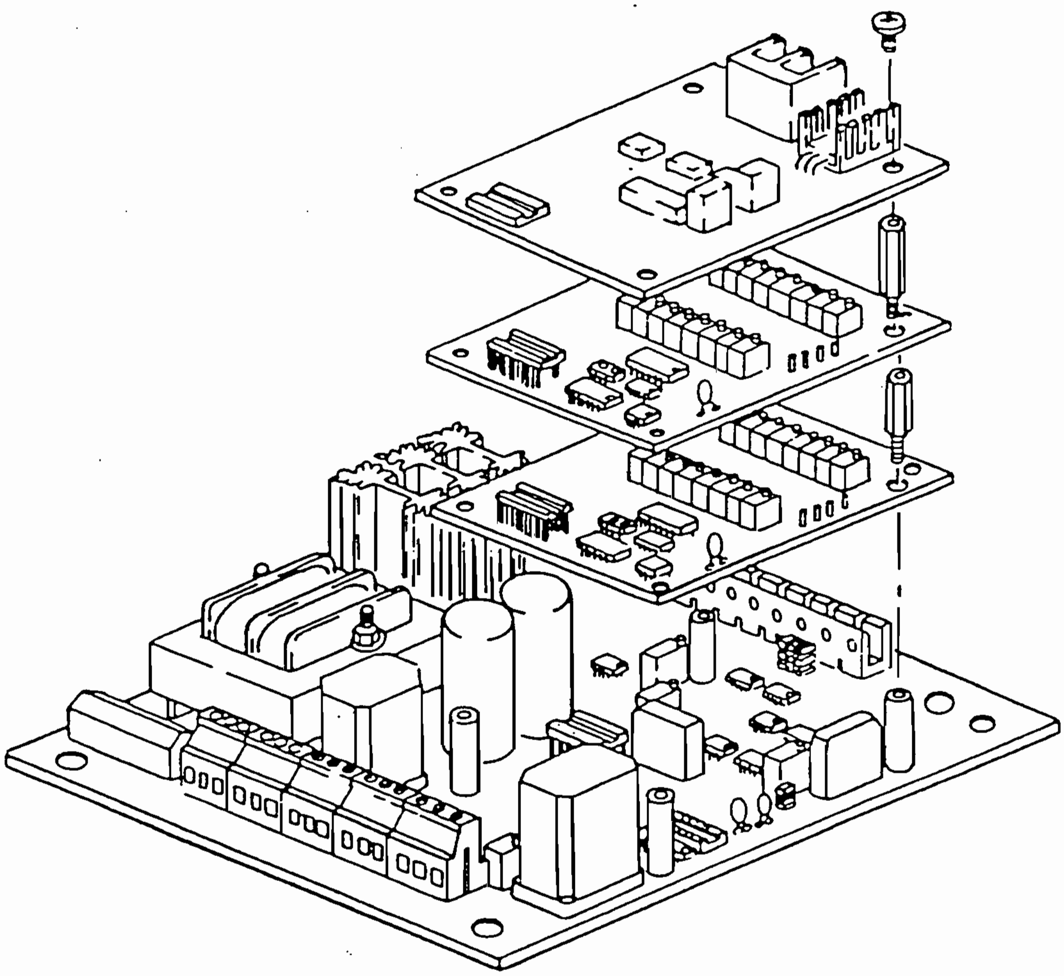


FIGURE 2-8
Dual Range Flowmeter Board Stack with Auxiliary Board

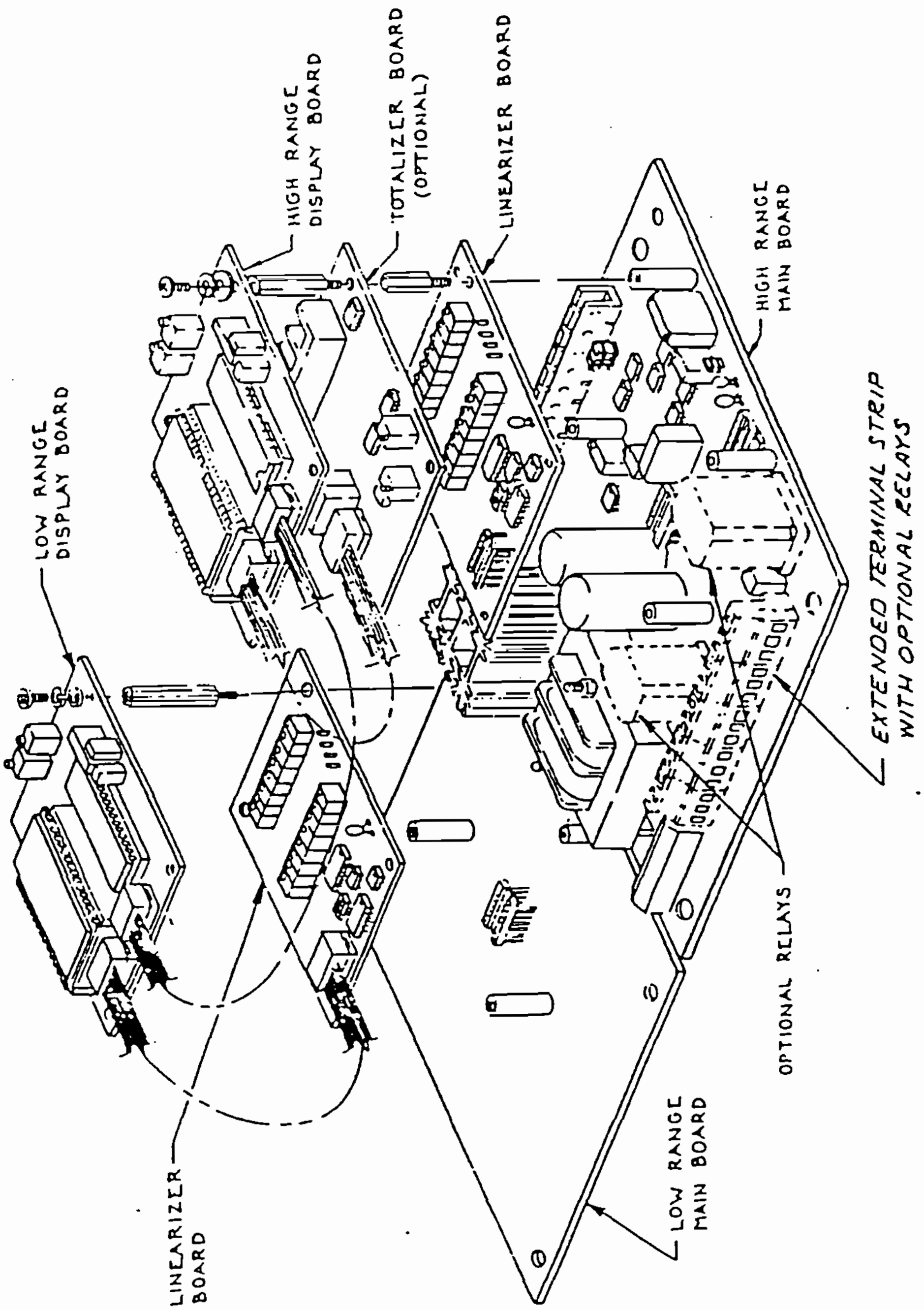


FIGURE 2-9
Dual Range Flowmeter with Totalizer and Dual Displays

SENSOR ASSEMBLY INSTALLATION

Before mounting the Sensor Probe Assembly you should check the options ordered for correct orientation and insertion length at the planned site of installation. Careful review of the next section prior to installation will ensure proper operation of the flowmeter.

MOUNTING LOCATION AND ORIENTATION

The Sensor Probe Thermowells must be positioned in the same orientation to the process flow as they were during calibration. Failing to install the Sensor Probe Assembly correctly may reduce the calibrated accuracy of your flowmeter. The plane defined by a line through the Sensor Probe Thermowells must be positioned perpendicular to the direction of process media flow (see Figure 2-10).

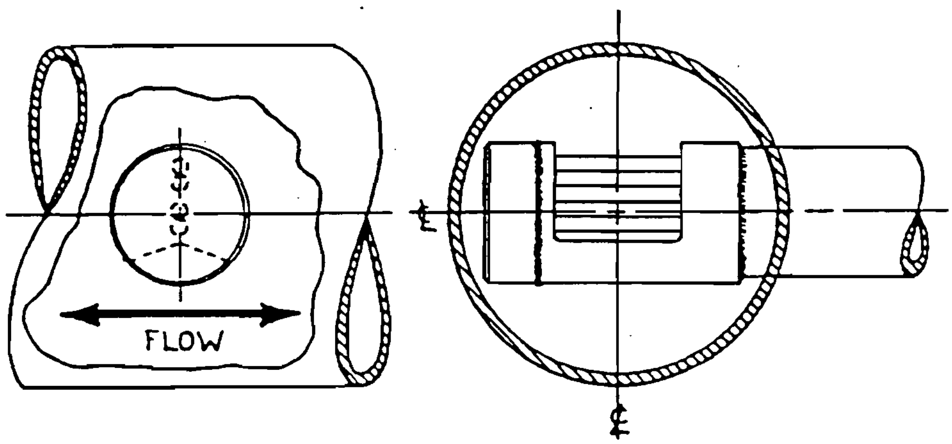


FIGURE 2-10
Thermowell Orientation

To aid in this critical adjustment, each LT81A Sensor Probe Assembly comes with a "Flat" machined on the Sensor Probe near the Terminal Strip Housing. The Flat is perpendicular to the Thermowell Plane. Adust the Sensor Probe Assembly during installation so the Flat is parallel, ± 2 degrees, to the direction of process media flow (see Figures 2-11 and 2-12).

The LT81A Sensor Probe Assembly should be installed with the thermowells across the cross-sectional-center of the process pipe or duct. In large pipes or ducts, the thermowells must extend at least 2" into the media. It is important that the sensor head not touch the walls of the pipe or duct.

For both flowmeters models, greatest accuracy is achieved when the Sensor Probe Assembly is mounted at least 20 diameters downstream and 10 diameters upstream from any bends or interference in the process pipe or duct.

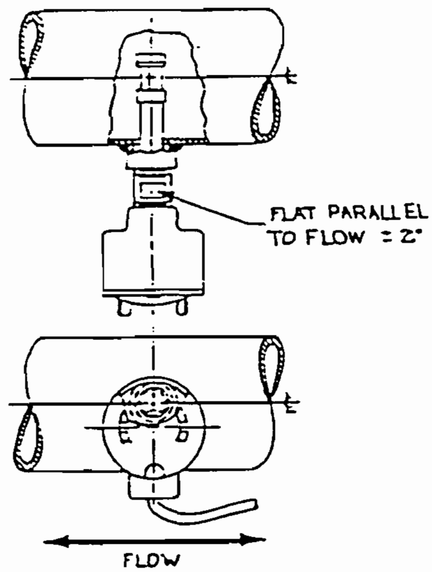
To prevent water damage, FCI recommends isolating the sensor assembly by using potting-Ys or other suitable moisture barriers. Ensure that appropriate gaskets, O-rings, and washers are correctly installed. Do not overtighten the sensor assembly during installation.

CAUTION: Damage resulting from moisture penetration of the sensor or electrical assembly is not protected by the product warranty.

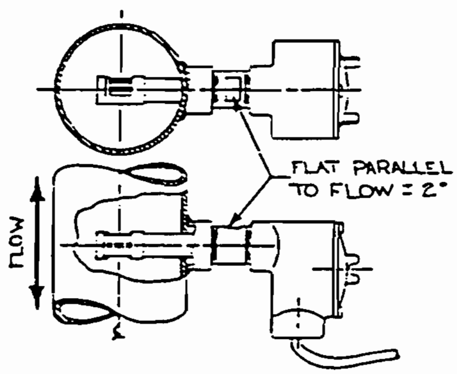
The "Side Mount" is preferred with the LT81A for horizontal flow. Be sure the flowmeter was ordered for a side mount. In applications where flow is vertical, greater accuracy will be achieved if the unit is mounted where flow is upward.

For horizontal flow with an LT81A, the flowmeter can be ordered for either a "Top or Bottom Mount". In these configurations, the "FLAT" or flow arrow should be positioned parallel to the flow. The accuracy of the calibration is degraded if the flow arrow is reversed from the flow direction of the media. Figure 2-12 illustrates these configurations.

The LT87 sensor is marked with a "flow arrow" and a "FLAT" based on the ordered configuration. It should be mounted in the process pipe with the "FLAT" within +/- 2 degrees of flow. The flow arrow should be pointed in the direction of media flow in order to achieve the calibrated accuracy. This is especially important on the LT87-4IT because these models are equipped with injection tubes.

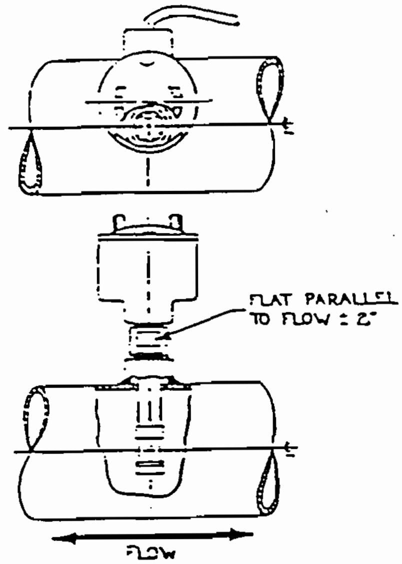


Horizontal Flow

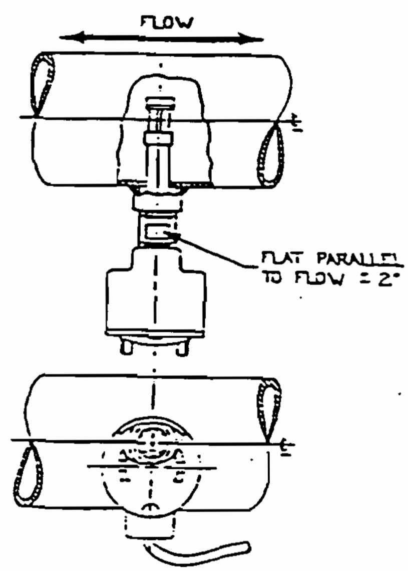


Vertical Flow

FIGURE 2-11
LT81A Side Mount - Preferred Mount



Top Mount



Bottom Mount

FIGURE 2-12
Alternate Mounts - Horizontal Flow Only

NOTE: Injection tube units (Model LT87-4IT) may not give correct readings when installed in the reverse flow direction.

MOUNTING INSTRUCTIONS

When mounting the Sensor Probe Assembly to the process, it is important that you apply a lubricant/sealant to the male threads of all connections. Be sure to use a lubricant/sealant compatible with your process environment. FCI recommends using a pipe wrench for 1 1/4" or larger connections and an open-end wrench for 1" or smaller connections. All connections should be tightened firmly. Avoid overtightening and binding threads or leaks may result.

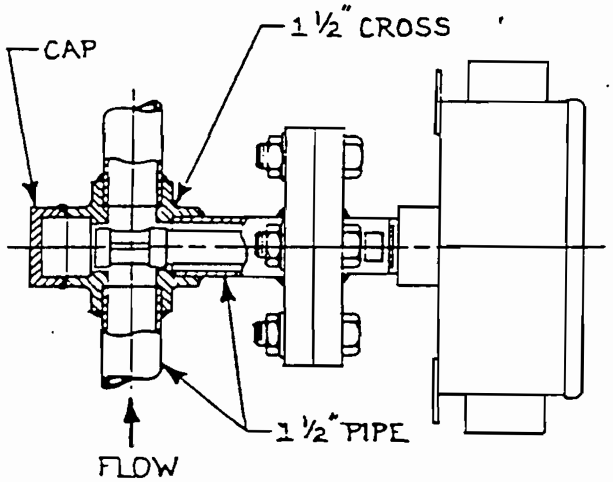
CAUTION: Damage resulting from moisture penetration of the electrical or sensor assembly is not covered by product warranty.

For flange mount Sensor Probe Assemblies, mount the process mating flange with care. The correct orientation of the sensor probe must be maintained to ensure the calibrated accuracy.

When mounting an LT87 in small process lines, you may want to consider using the optional mounting bracket. Make sure you orient the bracket such that the Sensor Probe Assembly will be positioned correctly when it is attached. Verify that the Process Media Flow is in the same direction as the arrow on the Flat.

CAUTION: Do not weld mounting bracket to sensor probe assembly or sensor probe assembly to a structural support.

In applications where an LT81A is to be mounted in a process pipe having an inside diameter less than 2", you may need to consider using one of the following configurations in order to position the sensing elements in the center of flow. Refer to Figure 2-13.



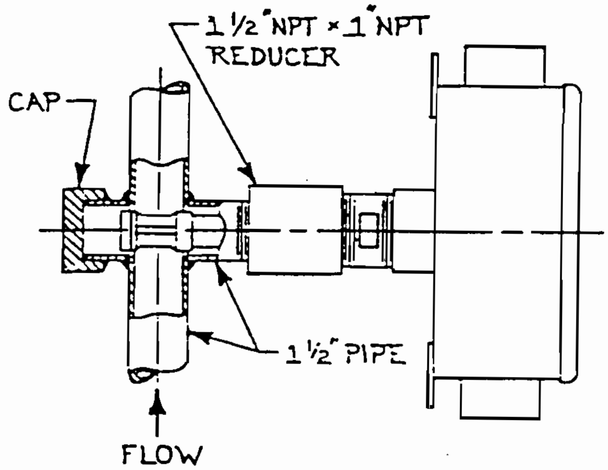


FIGURE 2-13
Mounting an LT81 in Smaller Pipes

ELECTRICAL WIRING INSTALLATION

CAUTION: Installation of an FCI Mass Flowmeter should only be performed by properly trained personnel in accordance with the current edition of the National Electrical Code.

On a standard flowmeter, the only electrical connections you will need to make are to the AC power lines and the flowmeter Output Signal. If the flowmeter is equipped with the optional switch point relays, then you will want to connect these to the process control or monitoring system. In a dual range flowmeter, you will need to make connections to both Output Signals. When the flowmeter is configured for remote electronics, you will also need to make the Sensor Probe Assembly connections.

WARNING: When installing an FCI Flowmeter, ensure that all power is off except where otherwise noted. When the manual requires the use of electrical current, the operator assumes all responsibility for conformance to safety standards and practices.

NOTE: FCI recommends the installation of an AC line fuse and switch between the AC power source and the flowmeter to allow for easy power disconnection during calibration and maintenance procedures.

NOTE: Unauthorized diagnostics or repairing may damage the board and/or components. Only qualified technicians should attempt repair of FCI instruments.

All electrical connections are to be made through the 1 1/14" FNPT opening in the electrical housing. FCI strongly recommends that all electrical cables be run through an appropriate conduit for the protection of the instrument and personnel. In applications where the Sensor Probe Assembly is located in an explosive environment, isolate the conduit before it leaves the environment. A potting "Y" may be used to provide the isolation. See Figure 2-14.

CAUTION: Damage resulting from moisture within the electronics assembly or sensor probe assembly is not covered by product warranty.

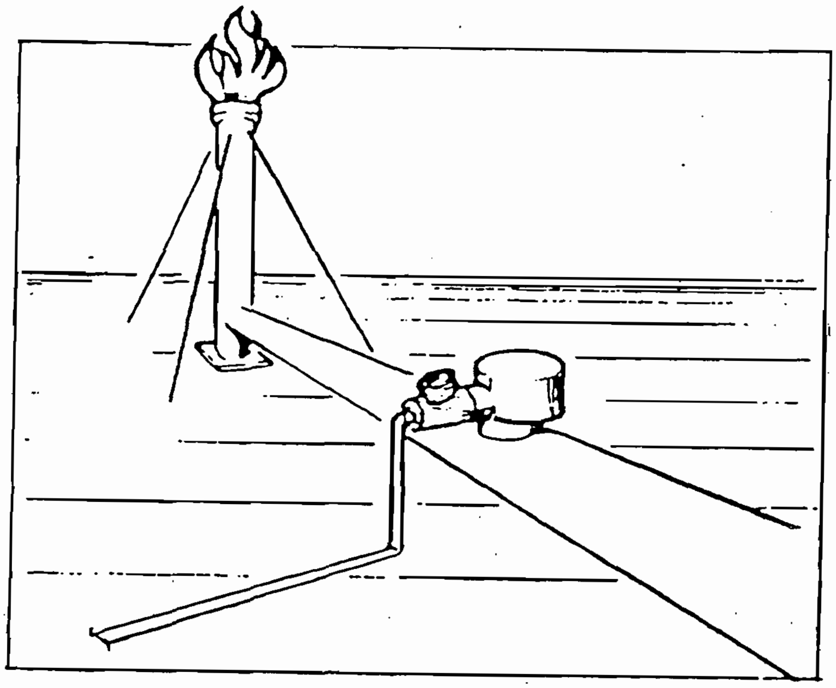


FIGURE 2-14
Explosive Environment Isolation

NOTE: Ensure that appropriate gaskets, O-rings, and washers are correctly installed.

FCI recommends that you remove the circuit boards while pulling the necessary cables to prevent damaging the circuit boards or their components. Please review the instructions below before attempting to remove the circuit boards.

CIRCUIT BOARD REMOVAL AND INSTALLATION

CAUTION: Power must be off before removing or installing a circuit board.

REMOVING A CIRCUIT BOARD

Before removing a circuit board, disconnect all external wiring to the board. Next, remove the retaining screws or threaded standoffs. Use caution when lifting the circuit board out to prevent damaging the bottom of the board or the components. To remove the main flowmeter circuit board, grasp the three heatsinks adjacent to the transformer on the board and lift that edge of the board until it clears the housing. When removing a stacked board, take care not to bend the pins on the interconnecting plug.

INSTALLING A CIRCUIT BOARD

Carefully position the circuit board making sure there are no wires caught between the board and adjacent surfaces. For stacked boards, you will need to take care not to bend the inter-connecting pins. Replace all retaining screws and/or threaded standoffs. Tighten the screws and/or standoffs so that they will not work loose. DO NOT over tighten the circuit board fasteners or you may crack the board. After mounting each board, connect its external wires following the wiring diagram carefully to prevent damage when power is applied.

NOTE: Turn the clamp screws of terminal strip TS2 on the main circuit board fully counterclockwise before attempting to insert wires. If this is not done, it is possible to insert the wire between the top half of the clamp and the frame rather than between the clamp halves.

WIRE GAUGES AND WIRING DIAGRAMS

The following table shows the smallest (maximum AWG number) copper wire which should be used in the electrical cables. Contact FCI concerning greater distances.

CABLE LENGTH

Connection	10 FT	50 FT	100 FT
AC Power	22	22	22
Relay * (2A)	28	22	20
(10A)	22	16	12
Sensor Wires	24	24	24
Heater Wires	24	24	24

CABLE LENGTH

Connection	250 FT	500 FT	1000 FT
AC Power	20	18	16
Relay * (2A)	16	12	10
(10A)	8	6	N/R
Sensor Wires	24	24	24
Heater Wires	24	22	22

* Ensures a maximum 2 volt drop over the cable length. Use a lower gauge for less drop.

Figure 2-15 is the external wiring diagram for an integral flowmeter. Figure 2-16 is the external wiring diagram for a remote Flowmeter. Refer to the "Electrical Housing and Board Stack" section of this manual for the correct inter-connections for your circuit board stacks.

NOTE: In applications where the Output Signal of the flowmeter is not being used, install a jumper between the "OUT+" and the "OUT-" terminals of the main flowmeter board.

Maximum load for the various output signals is:

OUTPUT SIGNAL	LOAD
4-20 mA	1200 ohms maximum
10-50 mA	500 ohms maximum
0-5 Vdc	Max. Current; 2 mA
1-5 Vdc	Max. Current; 2 mA
0-10 Vdc	Max. Current; 2 mA

CAUTION: In a remote configuration, it is essential for proper operation that separate excitation and sense wires be run for the "Active", "Reference", and "Ground". Refer to the "Theory of Operation".

GROUNDING AND SHIELDING

CAUTION: The LT81A/LT87 output signal, ("OUT+" and "OUT-"), CANNOT BE GROUNDED. Grounding of this output signal will cause SEVERE DAMAGE to the circuit board.

NOTE: When the sensor probe is connected to the electronics by remote cable, the cable shield is ONLY connected to the circuit board (TS2 "GND" terminal).

EXTERNAL WIRING

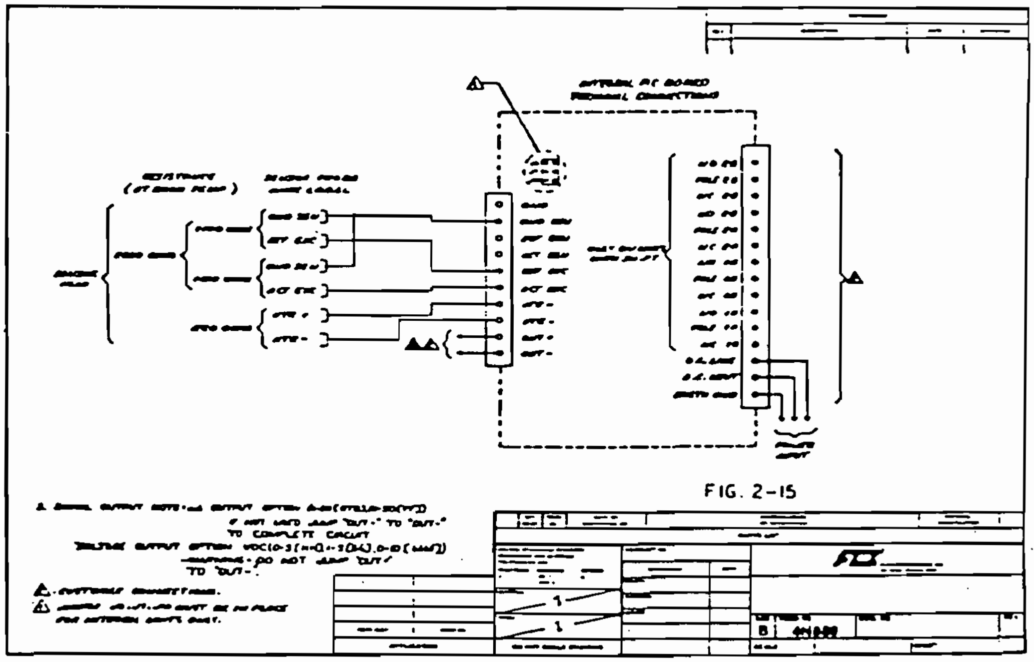


FIGURE 2-15
Integral Installation Wiring

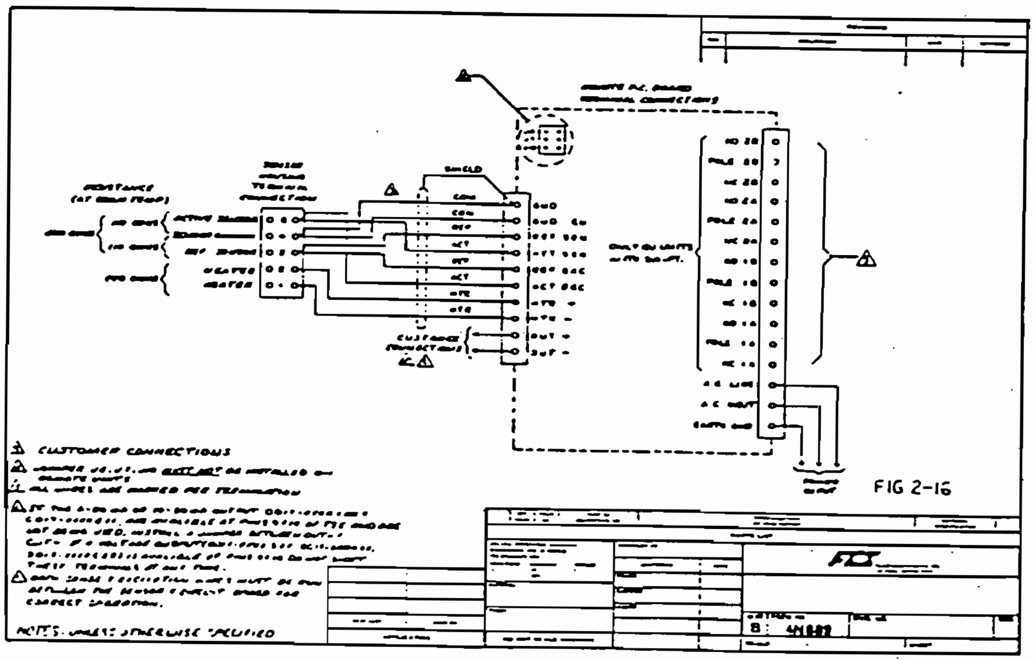


FIGURE 2-16
Remote Installation Wiring

EXTERNAL WIRING

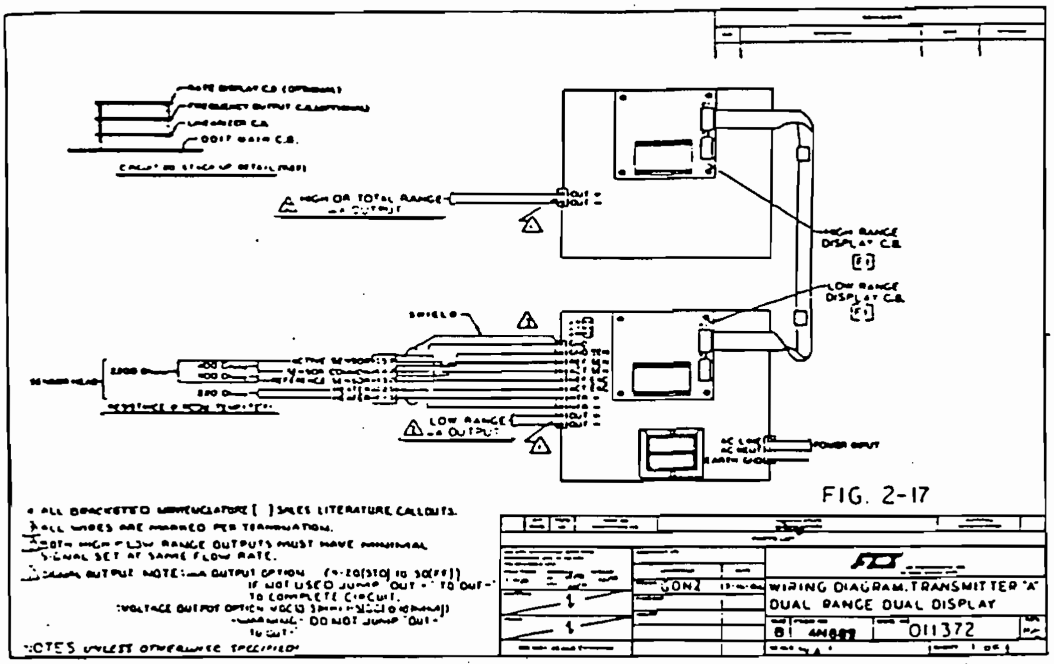


FIGURE 2-17
Dual Range with Totalizer and Dual Displays

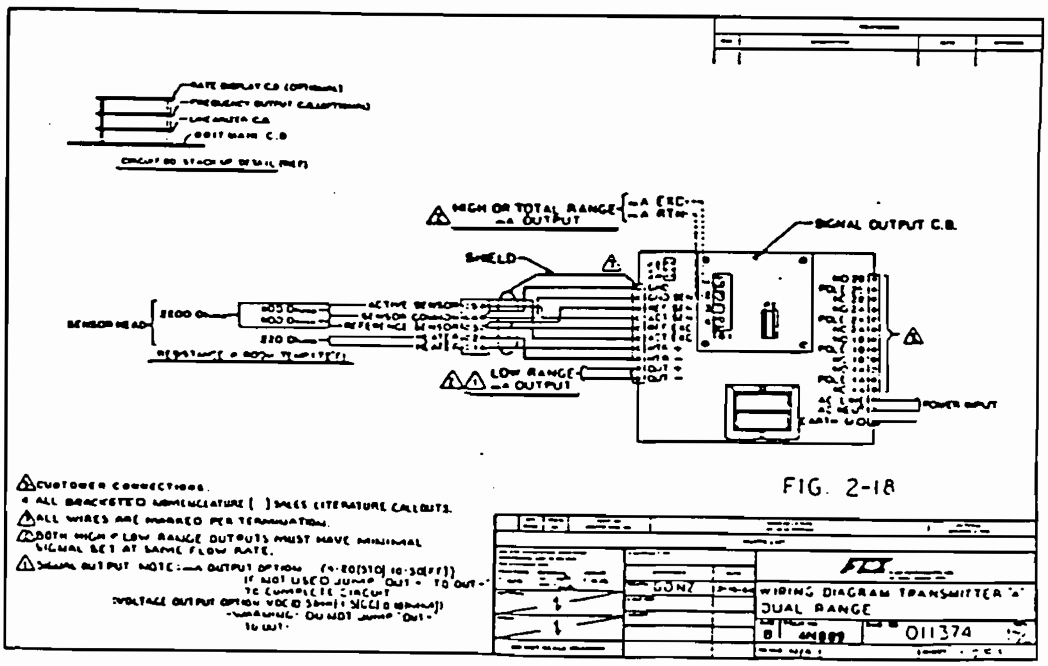


FIGURE 2-18
Dual Range without Displays

Best Available Copy

EXTERNAL WIRING

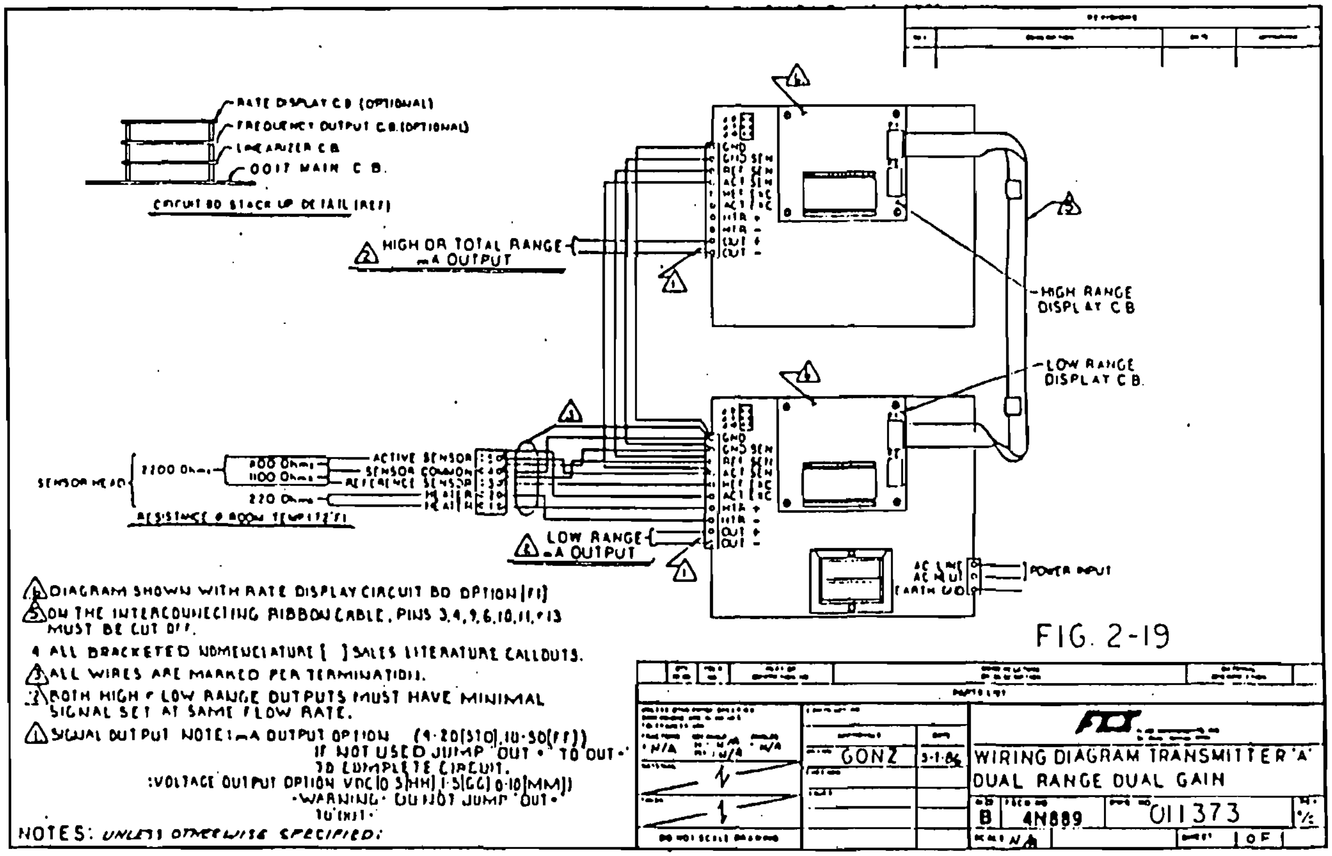


FIGURE 2-19
Dual Range Dual Gain

ELECTRICAL CALIBRATION

The electronics for the LT87 and the LT81A are identical. The calibration procedures described in this section apply to both models. FCI recommends that the appropriate verification and/or calibration procedures be performed every 12 months, or less in harsh environments or critical applications.

This section describes both a Flowmeter Verification Procedure and a Flowmeter Calibration Procedure. The Flowmeter Verification Procedure is to be followed in either case.

Only certain functions of the flowmeter's electronic circuits are designed for field calibration. Adjustment of any potentiometer other than those explicitly named in the calibration procedures will invalidate the factory calibration of the instrument. Do not attempt to repair an FCI Flowmeter without reviewing the REPAIR AND MAINTENANCE section of this manual.

WARNING: When installing the flowmeter, ensure that all power is off except where otherwise noted. When the manual requires the use of electrical current, the operator assumes all responsibility for conformance to safety standards and practices. To avoid injury and electrical shock, as well as damage to the transmitter, only perform the servicing procedures contained in the manual.

FCI makes a calibration instrument, FC81 Field Calibrator, which simplifies the verification and/or calibration of an FCI Flowmeter. The field calibrator replaces both the accurate milliammeter and the precision resistance decades used in the verification and calibration procedures. This instrument is convenient, compact, and operates off of the circuit board power (no external power required).

Calibration of the flowmeter options depends on the accurate calibration of the output signal. Therefore, before attempting to verify or calibrate optional switch points, the totalizer, or the local display, always verify the calibration of the output signal.

NOTE: These procedures will work for either the standard Output Signal of 4-20 mA or any of the optional Output Signals. The term low-limit signal will mean either 4 mA or 10 mA for the current loops, or 0 Vdc or 1 Vdc for the voltage outputs. Similarly, the term high-limit signal will mean either 20 mA or 50 mA for the current loops, or 5 Vdc or 10 Vdc for the voltage outputs.

Since there are often interactions between calibration adjustments, you should resist the temptation to adjust potentiometers whenever the present reading is within the specified tolerance. When adjustment is indicated by the verification procedure, you will be referred to a specific step, say cl2, in the calibration procedure. The calibration procedure then refers you back to the appropriate step, say vl8, in the verification procedure upon completion of the adjustments. Fold-out Figure 2-24, located at the end of this section shows the location of the adjustment potentiometers, test points, and calibration switch.

The "Physical Description" section of this manual explains how to access the circuit boards.

If the board stack in your Flowmeter includes both the frequency output board (part of the totalizer option) and the local display option, then you will need to remove the display board in order to make calibration adjustments on the frequency output board. You should review the section "Electrical Wiring Installation" before removing or installing circuit boards. You may also want to consult the description of the board stack for your transmitter in the section "Physical Descriptions".

NOTE: If it is necessary to continue totalizing the flow from its current value, then you will want to turn off the power and unplug the Veeder Root Counter from its socket while performing the Flowmeter Verification and/or Calibration Procedures.

NOTE: If the flowmeter is equipped with a local display, then you will need to remove this board from the stack in order to access the terminal strip. Leave the display board off until you are ready to verify its calibration. Refer to the "Electrical Installation and Wiring" section for assistance in removing the boards.

CAUTION: Turn power off when removing or installing circuit boards.

FLOWMETER VERIFICATION PROCEDURES

Read each step and, where present, its half step (for example, step v5 and v5.5) completely before performing any action.

PREFERRED OUTPUT SIGNAL VERIFICATION

v1: The preferred method for verifying and calibrating the Output Signal requires the following: the "Delta R Table" shipped with the flowmeter to be calibrated (Figure 2-20 shows a typical Delta "R" Table); an accurate (.01%) resistance decade (Gen Rad 1433-T or equivalent) and a precision (0.01%) 1000 ohm resistor (or a second accurate resistance decade); a milliammeter accurate to 0.05 mA for current loop outputs or a digital voltmeter accurate to 1 mV for the voltage outputs.

NOTE: If a milliammeter is not available for the current loop output, then a digital voltmeter may be substituted by connecting it across the output load and calculating the current. The accuracy of the verification or calibration depends on the accuracy of this calculation.

(If a resistance decade is not available, skip to Step v12, "Alternate Signal Output Verification".)

NOTE: The FC81 Field Calibrator replaces the resistance decades and the milliammeter. If you are using the Field Calibrator, follow the procedure in the FC81 Manual.

NOTE: As of January, 1986, all Flowmeters have been calibrated and linearized 20% beyond the maximum range parameter requested, when feasible. If the original maximum flow rate was underestimated at the time of purchase, you may be able to extend the original range by 20% without degrading the Factory Calibration. To verify the maximum calibrated range of your instrument, contact the FCI Test Department.

v2: Turn off power.

v3: Disconnect the wires to GND, GND SEN, REF SEN, ACT SEN, REF EXC, and ACT EXC on terminal strip TS2. If the output signal is a current loop, then also disconnect the output load wires to "OUT+" and "OUT-". (Leave the "HTR EXC" and "HTR RTN" connected.)

v4: Connect the resistance decades or precision resistor and decade to the circuit board as shown in Figure 2-21. Set the decade(s) for 1000 ohm.

v5: For the current loop outputs, connect the milliammeter between the "OUT+" (positive lead) and "OUT-" (negative lead) and select a range appropriate for your output current.

For the voltage output signals, connect a Digital Volt Meter (DVM) across the "OUT+" and "OUT-" terminals.

v5.5: If the flowmeter has the dual range option and you have a second meter, then connect it in a similar fashion to the low flow range output.

If you don't have a second meter, verify the low flow range output first. Leave the total flow range output load connected.

v6: Turn on power and allow the instrument 5 minutes to stabilize.

FCI FLUID COMPONENTS, INC.
1755 La Costa Meadows Drive, San Marcos, California 92069

DELTA "R" DATA SHEET

SHOP ORDER # ____________

CUSTOMER ____________

HEATER VOLTAGE ____________

DATE ____________

SERIAL # ____________

ΔR	mA	VOLTAGE IN NON-LINEARIZED (PINS 6 & 7)	VOLTAGE OUT LINEARIZED (PINS 5 & 7)	*DISPLAY
18.14	4.01	-0.001	+0.003	
17.50	4.50	+0.157	+0.078	
17.00	4.88	+ 0.281	+0.142	
15.15	7.01	+0.742	+0.499	
13.67	10.02	+1.109	+1.004	
12.62	13.01	+1.371	+1.506	
11.73	16.00	+1.592	+2.008	
10.79	20.01	+1.826	+2.680	
10.00	23.37	+2.022	+3.244	

FORM 703102 12-18-84 *When LOCAL DISPLAY INDICATOR option is used

FIGURE 2-20
Typical Delta "R" Table

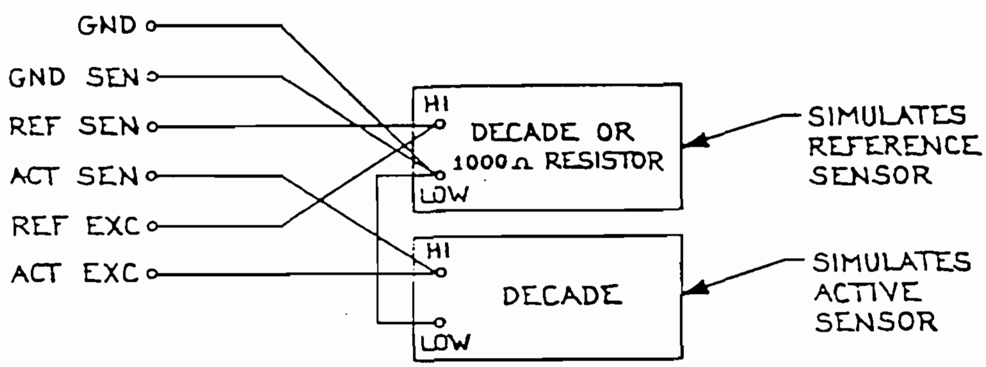


FIGURE 2-21
Decade Box Wiring Diagram

v7: Increase the decade resistance connected to the active terminal by the value shown in the Delta "R" column for the low-limit signal; that is, set the Active decade for a resistance of 1000 + Delta "R". The reading on the meter should be within 2% of the full signal range. Example: 4-20 mA Output Signal equals 2% of 16 mA equals 0.32 mA.

v7.5: If the flowmeter is a dual range instrument, then be sure to use the Delta "R" Table corresponding to the range where the meter is connected.

v8: Repeat step v7 for the other flow rates in the Delta "R" Table for your flowmeter.

v8.5: If you have a second meter connected to the low flow range of a dual range flowmeter, then repeat step v7 for the Delta "R" Table for this range.

v9: If the readings are not in tolerance, go to Step c1 in the Flowmeter Calibration Procedure.

v10: Turn off power and disconnect the decade resistors. Connect the proper wires from the sensor head to terminals ACT EXC, ACT SEN, REF EXC, REF SEN, GND, and GND SEN. Leave the meter connected at the output load.

v10.5: If you have a dual range flowmeter and only one meter, then leave the decade resistors connected. Turn off power. Move the meter to the total flow range load. If the output signal is a current loop, be sure to connect the low flow output load. Repeat steps v6 through v10 as though this were a signal range flowmeter.

v11: Skip to Step v18.

ALTERNATE OUTPUT SIGNAL VERIFICATION

v12: The alternate method for verifying the output signal requires that you have another method for accurately (better than 1%) determining the flow rate.

For a current loop output signal, turn off the power. Disconnect the wires to the "OUT+" and "OUT-" terminals on TS2 and connect a milliammeter. Turn on power.

For a voltage output signal, connect a digital voltmeter in parallel across the load terminals "OUT+" and "OUT-" on TS2. (Leave the output load connected.)

v12.5· If the flowmeter is a dual range instrument and you have only one meter, then perform steps v12 through v17 for the low flow range first and then the high flow range. Be sure to connect the output load for the range NOT being calibrated.

v13: Initiate a known flow rate at or near the lower end of the calibrated range (near the low-limit signal).

v14: Allow the flowmeter output signal to stabilize. Verify that the flow rate has remained constant. Compare the indicated flow rate to the actual flow rate. The indicated flow rate from the "mA Table" should be within 3% of Full Scale.

v15: Initiate a known flow rate near the high-limit and allow the flowmeter output signal to stabilize. Verify that the flow rate has remained constant. The indicated flow rate from the "mA Table" should be within 3% of the actual flow.

v16: If either the high or low limit value is out of tolerance, go to Step c1 in the Flowmeter Calibration Procedure.

v17: Set the Calibration Switch, SW1, on the main circuit board to the "CAL" position, away from the transformer, T1. See Fig. 2-24 at the end of this section.

v18: If the Flowmeter does not have the switch point relay options, then skip to Step v23.

SWITCH POINT VERIFICATION

v19: The optional switch point relays are located on the main circuit board. These switch points are totally independent of each other and can each be set to actuate at any point in the calibrated flow range.

The switch point relays can be either energized or de-energized prior to actuation by changing movable jumpers.

J1 and J2 are for Switch Point No. 1 (CR6, the red LED).

J3 and J4 are for Switch Point No. 2 (CR7, the green LED).

NOTE: Use fold-out Figure 2-24 to locate CR6 (the red LED), and CR7 (the green LED) on the main circuit board. CR7 will not be present on instruments having only one switch point. Consult the Flow Rate versus Current table or graph which was shipped with the flowmeter to determine the signal level at the desired flow rate. In the following procedure, when the part designation is different for switch points 1 and 2, the designation for switch point 2 will be enclosed in parenthesis.

v20: Adjust the Calibration Signal Potentiometer, R38, on the main circuit board until the signal level corresponds to the flow rate for switch point 1 (2).

v21: Vary the output signal, using R38, CAL POT, so that it moves through the desired switch point 1 (2) a few times while watching the red (green) LED to ensure that the switch point is set correctly. The LED will "light" when the test signal is above the switch point setting.

v22: If either switch point is out of calibration, go to Step c21 of the Flowmeter Calibration Procedure.

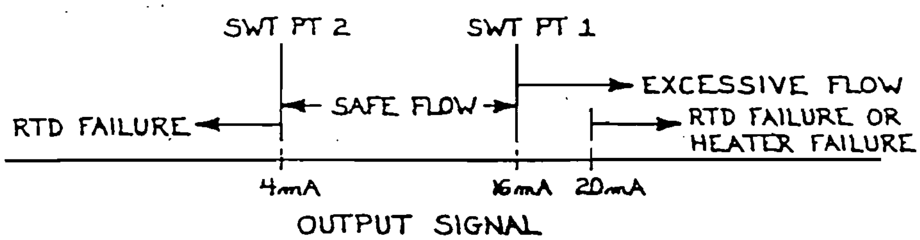


FIGURE 2-22
Detection of Sensor Failure

"FAIL-SAFE" SWITCHPOINT ADJUSTMENT

In most applications, a single switch point relay is required to indicate a flow rate which marks the boundary between safe and dangerous operation. If one of the RTD Sensors fail, the output signal will exceed one of the limits (for example, less than 4 mA or greater than 20 mA). By setting the second switch point to activate at an output signal limit on the safe side of the first switch point, the flowmeter can sound an alarm if a sensing element fails. Figure 2-22 illustrates one way to utilize this feature for a 4-20 mA output signal. In this example, an alarm will sound when a relay energizes.

v23: If the flowmeter does not have a totalizer option, skip to step v32.

TOTALIZER VERIFICATION

v24: The frequency output board generates a pulse train linearly proportional to the output signal. This pulse train has a 12 Vdc amplitude and a maximum frequency of 50 Hz. The pulses are totaled by a Veeder Root Electronic Counter with an eight digit liquid crystal display. The counter memory is powered by a ten year lithium battery so the accumulated count is retained during a loss of operating power.

If the low scale and full scale frequencies in pulses per second which correspond to the low-limit flow rate and the high-limit flow rate were not recorded at the time of calibration, you will need to calculate them. The unit to be totaled should result in an output signal from the frequency output board between 5 and 50 Hz at the high-limit flow rate. Lower frequencies may be used for the maximum flow rate with some increase in the calibration difficulty.

Examples:

A 4-20 mA output signal has been calibrated for flow range of 1 to 11 SCFS. The totalizer is counting standard cubic ft/sec; therefore it is reasonable to assume that the frequency output board was calibrated for a low scale frequency of 1 Hz and a high-scale frequency of 11 Hz.

Another instrument is calibrated for a 4-20 mA output over a 40 to 160 ft/sec flow rate in a process pipe having a cross-sectional area of .25 square feet. The totalizer is accumulating the ACFS. The high scale frequency should correspond to 160 x .25 = 40 ACFS and is therefore most likely to be 40 Hz.

As a third example, assume a flowmeter has been calibrated over a 2 to 20 SCFM flow rate. Note that the low and high flow rates must first be converted to a base of seconds before the frequency can be calculated. The 20 SCFM/60 sec/min equals .33 SCFS. This implies a top frequency of .33 Hz which is not in the 5-50 Hz range. However, multiplying by 100 gives 33 Hz which is within the calibration range. It is then necessary to add a decimal point to the display representing a division by 100. For example, the display would be 000056.45 when 56 SCFM had been totaled.

Calibration of the totalizer requires measuring the frequency of the pulse train output signal of the frequency board. This is most accurately accomplished by an electronic counter having good low frequency resolution.

NOTE: Under normal conditions, where the accumulated total is to be restarted after the calibration, a reasonable approximation can be made using the Veeder Root Counter. Time (in seconds) how long it takes the Veeder Root Counter to increase by 100 counts. Divide this number by 100 to get the period of one count and invert to get the approximate frequency (1/period = frequency).

v25: Connect the DC-coupled counter to terminal 1 (+) and terminal 2 (-) on the frequency output board. Refer to fold-out Figure 2-24.

v26: Move the CAL Switch, SW1, away from the transformer to the "CAL" position. Adjust the CAL POT, R38, on the main board until the meter reads the low-limit signal plus 0.2 mA (for current loops) or 50 mV (for voltage outputs). Verify that the counter indicates the low scale frequency +/- 2 counts.

v27: Adjust the R38 until the meter reads the high-limit signal +/- 0.1 mA (current loops) or +/- 25 mV (voltage output). Verify that the counter indicates the high scale frequency +/- 1 count.

v28: If either of the counter readings is not correct, go to Step c17 in the Flowmeter Calibration Procedure.

v29: Adjust R38 on the main circuit board until the meter reads the low-limit signal. Verify that the counter is not counting. Alternatively, verify that the voltage between pins 3 and 4 of the terminal strip on the frequency output board is considerably lower than 1 Vdc.

v30: If the counter is still counting, go to Step c26 in the Flowmeter Calibration Procedure.

v31: Disconnect the counter.

v32: If the Flowmeter does not have the local display option, skip to Step v37.

LOCAL DISPLAY VERIFICATION

v33: If the local display board has been removed, turn off power. Install the display board. Turn on power and allow the flowmeter signal 5 minutes to stabilize.

v33.5: If the Flowmeter is a dual range instrument with two displays, you will need to perform steps v33 through v36 for each display. Be sure to turn off power if you need to move the milliameter to the other range.

v34: Move Calibration Switch, SW1, away from the transformer to the "CAL" position. Adjust R38, CAL POT, on the main circuit board until the meter reads the low-limit signal +/- 0.5% of the high-limit signal value (0.1 mA or 25 mV). Verify that the local display indicates the correct reading for the low-limit flow plus or minus 1 digit.

v35: Adjust R38 on the main board until the meter reads the high-limit signal +/- 0.5% of the high-limit signal value (0.1 mA or 25 mV). Verify that the local display indicates the correct reading for the high-limit flow plus or minus 1 digit.

v36: If either value is out of tolerance, go to Step c30 in the Flowmeter Calibration Procedure

VERIFICATION COMPLETION

v37: Turn off the power.

v38: If the Veeder Root Electronic Counter was disconnected, perform step a; otherwise, perform step b.

a) Remove the display board. Connect the Veeder Root counter to pins 1 (+) and 2 (-) on the terminal strip on the frequency output board. Install the display board.

b) Zero the Veeder Root Counter by shorting together the pins of the terminal strip marked "TOTALIZER RESET" inside the electronic enclosure. In some applications, these two pins will have been brought out to a switch which can be used to reset the totalizer without opening the enclosure.

v39: Disconnect the milliammeter. Connect the output load to the "OUT+" and "OUT-" terminals on the main board.

v40: Move Calibration Switch, SW1, on the main board toward the transformer to the "OP" position (OPERATE Position).

v41: Close the electrical assembly housing making sure that none of the wires are caught. Ensure that all seals, gaskets, and O-rings are properly installed.

CAUTION: Damage resulting from moisture penetration of the sensor or electrical assembly is not covered by the product warranty.

FLOWMETER CALIBRATION PROCEDURE

NOTE: The calibration procedure requires that you follow the "Flowmeter Verification Procedure." This is NOT an independent procedure.

Not adjusting potentiometers when a value is within tolerance will decrease the time required to calibrate the flowmeter.

PREFERRED OUTPUT SIGNAL CALIBRATION

c1: Connect the DVM to the +10 Vdc reference, pins 12 (+) and 7 (-) of the test plug "P1". The measured voltage should be +10 Vdc +/-10 mV. R33, +10 Vdc ADJ may be adjusted, if necessary, to obtain +10 Vdc. Remove the DVM.

c2: Turn off power and connect a milliammeter in series with the Heater.

c3: Turn on power and verify that the heater current is equal to the value recorded on the Delta "R" Table for this flowmeter +/-1 mA. If necessary, adjust R48, HTR, for this current.

c4: Turn off power, remove the milliammeter, and connect the Heater.

c4.5: Determine if U17 is installed (temperature compensated units only). Refer to Figure 2-24 for its location. U17 is a 16-pin hermetically sealed can in a socket. If U17 is present, carefully remove it and install a 24 AWG jumper between pins 1 and 2 of its socket. It is necessary to remove and replace the linearizer board to perform this operation.

c5: Short the ACT SEN and REF SEN terminals together (This can be done by turning either Jumper, J7 or J8, ninety degrees on integral Flowmeters.

c6: Connect the DVM between pins 12 (+) and 6 (-) on the test plug. The meter must not have either input connected to ground. Turn on Power.

c7: Verify that the DVM reads 0 Vdc +/- 5 mV. Adjust potentiometer R15, NULL, on the main circuit board if necessary for zero volts.

c8: Remove the short between ACT SEN and REF SEN. If you have moved the meter connected to the output load, connect it back to the "OUT+" and "OUT-" terminals.

c9: Determine the amplifier gain from the part number (see Appendix "A"). Set the "Active" decade to the value given in TABLE 1 and verify that the DVM measures +5 Vdc +/- 10 mV. Potentiometer R17 is used to adjust this value. Reinstall U17 if it has been removed.

TABLE 1

GAIN	ACTIVE DECADE SETTING
50	1100 OHMS
100	1050 OHMS
200	1025 OHMS
400	1012.5 OHMS
800	1006.25 OHMS

DECADE SETTINGS FOR THE GAIN ADJUST

c10: Set the active decade to 1000 ohms plus the resistance indicated at the low-limit signal in the Delta "R" Table. Adjust potentiometer R19, ZERO, on the main circuit board until the output of the meter reads the low-limit signal +/- 2% of the signal range; 0.32 mA or 0.80 mA for the current loops and 0.1 Vdc or 0.2 Vdc for the voltage out-puts.

c10.5: When calibrating the low flow range on a dual range flowmeter configured with an auxiliary output board, the ZERO pot is R10. Refer to fold-out Figure 2-24.

c11: Set the active decade to 1000 ohms plus the resistance indicated at the high-limit signal in the Delta "R" Table. Adjust R24 (SPAN) on the main circuit board until the meter reads the high-limit signal value +/- 2% (as in step c10).

c11.5: When calibrating the low flow range on a dual range Flowmeter using an auxiliary output board, the SPAN pot is R11.

c12: Repeat steps c10 and c11 until both limits are within tolerance.

c13: Return to Step v7 in the Flowmeter Verification Procedure.

ALTERNATE OUTPUT SIGNAL CALIBRATION

c14: Perform steps c1 through c8 above.

c15: Initiate the flow rate near the low-limit and allow the Flowmeter signal to stabilize.

c16: Adjust R19 (ZERO) on the main circuit board until the meter reads the value +/- 2% of the full range (0.32 mA or 0.80 mA for the current loops and 0.1 Vdc or 0.2 Vdc for the voltage output).

c16.5: When calibrating the low flow range on a dual range instrument configured with an auxiliary output board, the ZERO pot is R10. Refer to fold-out Figure 2-24.

c17: Initiate a flow rate near the high-limit and allow the Flowmeter signal to stabilize.

c18: Adjust potentiometer R24 (SPAN) on the main circuit board until the meter reads the value given in the Delta "R" Table +/- 2% of the signal range (as in step c16).

c18.5: When calibrating the low flow range on a dual range instrument using an auxiliary output board, the SPAN pot is R11.

c19: Repeat steps c15 through c18 until both values are within tolerance.

c20: Return to Step v17 of the Flowmeter Verification Procedure.

SWITCH POINT CALIBRATION

c21: Adjust the **CAL POT**, R38, on the main circuit board until the meter reading indicates the signal value corresponding to the flow rate for switch point 1 (2).

c22: If the switch point indicator red (green) LED, CR6 (CR7), is "on", then turn the switch point pot, R9 (R16), on the main circuit board counter-clockwise until the LED goes "off".

c23: Starting with LED "off", slowly turn R9 (R16) clockwise until the LED just turns "on".

c24: Vary the output signal, using R38 (calibration pot), so that it moves through the desired switch point a few times while watching the LED to ensure that the switch point is set correctly. If necessary, repeat steps c21 through c24 to correct the switch point setting.

c25: Return to Step v23 in the Flowmeter Verification Procedure.

TOTALIZER CALIBRATION

NOTE: Please read Totalizer Verification Section v-24 before proceeding to totalizer calibration.

c26: If a Flowmeter has the local display option, you must remove the display board in order to make adjustments on the frequency output board.

CAUTION: Turn power off before removing or installing a circuit board.

Example:

A 4-20 mA Output Signal calibrated for a flow rate of 1 to 11 SCFS will be used as the example in the procedure for calibrating the totalizer. The Totalizer will be accumulating the total standard cubic feet of medium passing the sensor probe.

c27: Adjust R38, CAL POT, on the main circuit board until the meter reads the low-limit signal +/- 0.1 mA for a current loop or +/- 25 mV for a voltage output.

Example:

Adjust R38 until the milliammeter reads between 3.9 and 4.1 mA.

c28: Connect a DVM between test points TP1 and TP2 on the frequency output board. Turn the SPAN pot on the frequency board fully clockwise. Adjust the ZERO pot (R2) on the frequency board to yield a reading of 0 mV +/- 1 mV. Disconnect the DVM.

c29: Turn the OFFSET pot (R4) on the frequency output board fully counter-clockwise.

c30: Adjust R38 on the main board until the meter reads the high-limit signal +/- 0.1 mA for a current loop or 25 mV for a voltage output.

Example:

Adjust R38 until the milliammeter reads between 19.9 and 20.1 mA.

c31: Calculate the difference between the full scale frequency and the low scale frequency for the unit to be totaled. Adjust the SPAN pot on the frequency output board until the counter indicates a frequency equal to this difference.

Example:

Difference = 11 - 1 = 10. Adjust the SPAN Potentiometer (R12) until the counter reads 10Hz.

c32: Adjust the ZERO pot (R2) on the frequency output board until the counter indicates the full scale frequency.

Example:

Adjust ZERO until the counter reads 11 Hz.

NOTE: On zero based instruments, this adjustment will not be necessary.

c33: Adjust R38 until the meter reads the low-limit signal +/-0.1 mA for a current loop or 25 mV for voltage output. Verify that the counter indicates the low scale frequency.

Example:

Adjust R38 until the milliammeter reads between 3.9 and 4.1 mA. Verify that the counter reads 1 Hz.

NOTE: On zero based instruments, select a low limit value above the step, a value that gives greater than a 4.0 mA output.

c34: If the counter reading is not correct, then adjust the ZERO pot (R2) on the frequency output board to correct the reading. If adjustment is necessary use R38 to return to the high-limit signal and verify that the counter reads the correct full scale frequency. If adjustment is necessary, use the SPAN pot on the frequency output board. Alternate between the low-limit (adjusting ZERO) and high-limit (adjusting SPAN) signal until the counter reads correctly at both flow rates.

c35: Adjust R38 on the main circuit board until the meter reads the low-limit signal plus 0.1 mA for a current loop or 25 mV for a voltage output.

NOTE: Remember to turn off the power if you need to remove the display board for access to the frequency board.

Example:

Adjust R38 until the milliammeter reads 4.10 mA.

c36: Connect the DVM between terminals 4 (+) and 3 (-) on the frequency output board. If a DVM is not available, then you can observe the totalizer output while performing step c37.

c37: Turn the OFFSET pot (R4) on the frequency output board until the DVM reading switches from +1 Vdc to a lower value, or alternately, until the counter just stops counting. This adjustment prevents the totalizer from making false counts under drift conditions (below the minimum flow parameter).

c38: Return to Step v31 of the Flowmeter Verification Procedure.

LOCAL DISPLAY CALIBRATION

c39: The local display can be calibrated to display any linear relationship of the output signal. The display is only accurate over the calibrated flow range; flow rates outside of the calibrated flow range may not be accurate.

Example:

A 4-20 mA output signal has been calibrated for flow rates from 1 to 11 feet per second. The display can be calibrated to display feet per second directly or the equivalent cubic feet per minute. For the example Flowmeter in a 26.067 sq. in. cross-sectional pipe, the calibrated flow range would be:

1 FPS x (26.067 / 12 x 12) sq. ft. x 60 sec/min = 10.86CFM

11 FPS x 0.181 sq.ft. x 60 sec/min = 119.47 ACFM.

The desired position for the decimal point is determined by the high-limit flow value. The sequence 1999 is the maximum which can be displayed. The position of the decimal point is determined by jumper J1 on the display board. Refer to fold-out Figure 2-24 to locate the jumper. Use the following chart to determine the correct position of the jumper.

Jumper Location	Decimal Position
Omit	lxxx
A	lxx.x
B	lx.xx
C	l.xxx

Example:

To display a maximum flow rate of 11 ft/sec the jumper needs to be in position "B". However, to display the 119.5 CFM, the jumper needs to be in position "A".

NOTE: If the jumper needs to be moved, turn off power.

The equivalent flow range of 10.9 to 119.5 CFM will be used in the calibration procedure which follows.

c40: Adjust R38, CAL POT, on the main board until the meter reads the low limit signal +/- 0.1 mA for a current loop or 25 mVdc for a voltage output.

Example:

Adjust R38 until the meter reading is between 3.9 and 4.1 mA.

c41: Adjust the ZERO pot on the Display board for display reading of zero.

Example:

Adjust ZERO pot on the display shows "000.0".

c42: Adjust R38 on the main board until the meter reads the high-limit signal +/- 0.1 mA for a current loop or 25 mV for a voltage output.

Example:

Adjust R38 until the meter reading is between 19.9 and 20.1 mA.

c43: Adjust the SPAN pot (R2) on the display board for readout equal to the high-limit flow minus the low-limit flow.

Example:

Adjust SPAN until the display shows 108.6 (119.5 - 10.9).

c44: Adjust the Zero pot (R6) on the display board for a readout equal to the high-limit flow.

Example:

Adjust ZERO pot until the display shows 119.5.

c45: Adjust R38 on the main circuit board until the meter reads the low-limit signal. Verify that the display reading is within one digit of the low-limit flow.

Example:

Adjust R38 until the meter reads 4 mA. Verify that the display reading is between 10.8 and 11.0.

c46: If the low-limit display is not within one digit of the correct value, then adjust the ZERO pot on the display board. If adjustment is necessary, return to the high-limit flow (use R38) and verify that the high-flow is within one digit. If not use the SPAN pot on the display board to adjust the value. Alternate between these two values until both are correct.

c47: Return to Step v37 in the Flowmeter Verification Procedure.

ADJUSTING THE OUTPUT SIGNAL FOR A DIFFERENT FLOW RANGE

In some applications, you may find it desirable to adjust the Output Signal to operate over a flow range different from the calibrated flow range. In those cases where the desired flow range is within the calibrated flow range, such an adjustment can be made without degrading the linearity of the output signal.

The output signal typically requires only 60% of the available input signal from the sensor head, but is calibrated to utilize 100% of the input signal. The remaining 40% of the input signal is, therefore, available for adjusting the end points of the output signal. Hence, you may adjust the Output Signal to cover from 0-60% to 40-100% of the factory calibrated flow range.

NOTE: As of January, 1986, all FCI Mass Flowmeters are calibrated and linearized 20% beyond the maximum range parameter requested, when feasible. If the original maximum flow rate was underestimated at the time of purchase, you may be able to extend the original range by 20% without degrading the Factory Calibration. To verify the maximum calibrated range of your instrument, contact the FCI Test Department.

For increased clarity, an example application will be described along with the procedure for this adjustment. Use the fold-out Figure 2-24 to locate R19 (ZERO), R24 (SPAN), R38 (CAL POT), and SW1 (CAL SWT). You will need to construct a graph for Flow Rate versus Current for the flowmeter to be adjusted. Plot the output signal on the y-axis and the flow rate on the x-axis on cartesian graph paper. Draw a straight line between the point representing the low-limit signal/low-limit flow rate and the point representing the high-limit signal/high-limit flow rate. Figure 2-23 is the Flow Rate versus Current graph for the example problem.

Example:

The example Flowmeter for this procedure was calibrated with a 4-20 mA output signal over a flow range of 1 to 11 feet per second (FPS) in air. This flowmeter may be adjusted to give a 4-20 mA linear output from 1 to 7 FPS up to 5 to 11 FPS. Any range between 1 and 11 FPS is possible. However, ranges which include flow rates outside the 1 to 11 FPS range may not be possible without degradation of the calibration.

It is important that the following adjustments be made in the order given.

1. FOR CURRENT LOOPS: Turn off the power and disconnect the output signal load (disconnect the wires to the "OUT+" and "OUT-" terminals on the main circuit board). Connect a milliammeter between the "OUT+" (positive lead) and the "OUT-" (negative lead) terminals. Turn power on.

2. FOR VOLTAGE OUTPUTS: Connect a DVM across the "OUT+" and "OUT-" terminals on the main board. Turn power on.

3. Use the Flow Rate versus Current graph to determine the present output signal values for the desired flow rate limits. The present output signal for the desired lower flow rate limit will be referred to as the low-adjust signal in this procedure. Be sure to record the new flow rate limits or you will need to perform a re-calibration of the flowmeter to return to full-flow-range operation.

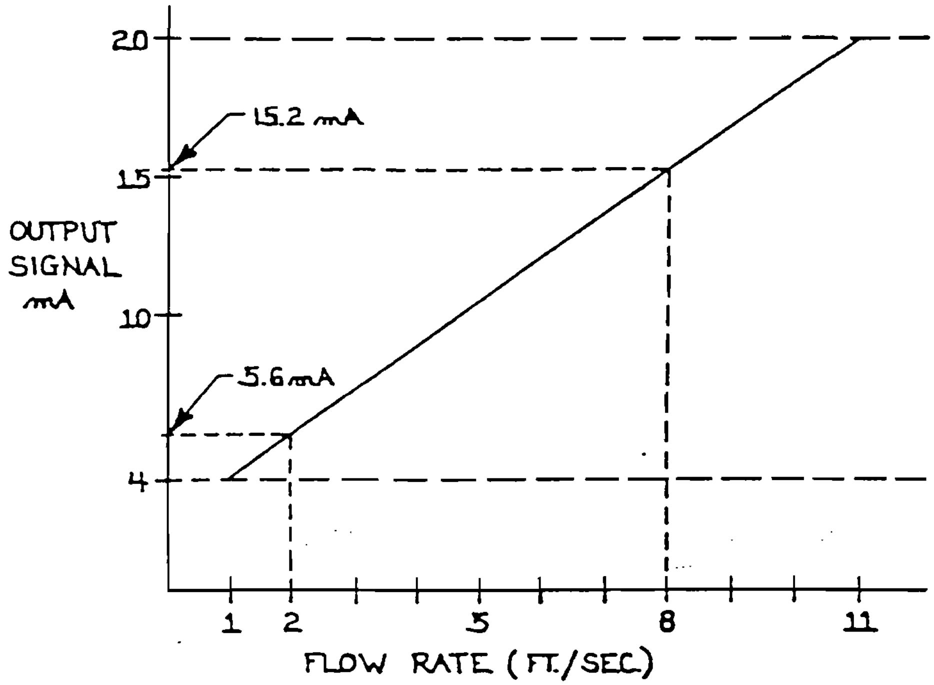


FIGURE 2-23
Flow Rate Versus Current Graph

Example:

The desired new values for the flow range are 2 FPS and 8 FPS. From the graph, Figure 2-23, the present values for these flow rates are 5.6 mA and 15.2 mA, respectively. Thus the low-adjust signal is 5.6 mA.

4. Subtract the low-limit output signal from the low-adjust signal. Subtract this difference from the new maximum output signal to obtain the high-adjust signal. Recording the low-adjust and high-adjust signals makes it easy to return the flowmeter to the full-flow-range operation.

Example:

difference = 5.6 mA - 4 mA
= 1.6 mA

high-adjust signal = 15.2 mA - 1.6 mA
= 13.6 mA

5. Use fold-out Figure 2-24 to locate the CAL SWT, SW1, and the CAL POT, R38 on the main circuit board. Move switch SW1 away from the transformer, and adjust R38 until the meter reading is the low-adjust signal.

Example:

Adjust R38 for a reading of 5.6 mA.

6. Locate the Zero adjustment potentiometer R19 and adjust until the meter reads the low-limit signal.

Example:

Adjust R19 until 5.6 mA changes to 4 mA.

7. Adjust R38 until the meter reading is the high-adjust signal calculated in step 4.

Example:

Adjust R38 until 4 mA changes to 13.6 mA.

8. Locate the Span adjustment potentiometer R24 and adjust until the meter reads the high-limit signal.

Example:

Adjust R24 until 13.6 mA changes to 20 mA.

9. Return CAL SWT, SW1, to the "OP" Operate position (toward the transformer). Turn off power. Disconnect the meter and if necessary connect the output load between the "OUT+" and "OUT-" terminals. If the flowmeter has options, then you will want to perform the Flowmeter Verification Procedure.

RETURNING OUTPUT SIGNAL TO THE FULL-FLOW-RANGE

Returning a Flowmeter to the full-flow-range can be accomplished in several ways. Performing the calibration procedure for the output signal is the preferred method. However, if you do not have an accurate resistance decade, you may want to use the following procedure. A third method is described in the section "Using the Delta R Table". The same example application used in the procedure for changing the flow range will be used here.

1. You will need the low-adjust and high-adjust signals as calculated in Steps 3 and 4 of the procedure above. If these were not recorded, then calculate them from the restricted flow range limits using the Flow Rate versus Current graph. If the restricted flow range limits were not recorded, then you will need to use either the "Flowmeter Calibration Procedure" or the method described in "Using the Delta R Table".

Example:

Low-adjust signal = 5.6 mA

High-adjust signal = 13.6 mA

2. FOR CURRENT LOOPS: Turn off power and disconnect the output load (disconnect the wires to the "OUT+" and "OUT-" terminals on the main circuit board). Connect a milliammeter to these terminals. Turn on power.

3. FOR VOLTAGE OUTPUTS: Connect a DVM across the "OUT+" "OUT-" terminals on the main board. Turn on power.

4. Locate switch SW1, CAL SWT, and potentiometer R38, CAL POT, on the main circuit board using fold-out Figure 2-24. Move SW1 away from the transformer. Adjust R38 until the meter reads the high-limit signal.

Example:

Adjust R38 until the meter reads 20 mA.

5. Locate Potentiometer R24 (SPAN) and adjust until the meter reads the high-adjust signal.

Example:

Adjust R24 until 20 mA changes to 13.6 mA.

6. Adjust the CAL POT, R38, until the meter reads the low-limit signal.

Example:

Adjust R38 until 13.6 mA changes to 4 mA.

7. Locate Potentiometer R19, ZERO, and adjust until the meter reads the low-adjust signal.

Example:

Adjust R19 until 4 mA changes to 5.6 mA.

8. Turn off power and disconnect the meter. If necessary, connect the "OUT+" and "OUT-" terminals to the output load resistor. Move the CAL SWT, SW1, on the main circuit board toward the transformer. The flowmeter is now operative over the entire calibrated flow range.

CHANGING VOLUMETRIC FLOW RATE FOR DIFFERENT PIPES

The Thermal Dispersion Type sensing elements of the LT81A and LT87 Mass Flowmeters directly measure mass flow rate (refer to the "Theory of Operation".) In applications where volumetric flow rate is desired, the mass flow rate is converted to volumetric flow using the continuity equation for steady state flow: $m = \rho AV$. Where m is the mass flow rate, ρ is the density, "A" is the cross-sectional area of the pipe, and "V" is the average velocity. The volumetric flow rate is the product of the cross-sectional area and the average velocity: $AV = m/\rho$.

Thus, for the same flow velocity, the new volumetric flow rate is given by:

$$Vn = Vc \times An/Ac$$

where Vn = new volumetric flow,
Vc = calibrated volumetric flow,
Ac = calibrated cross-sectional area, and
An = new cross-sectional area.

To determine the new volumetric flow range when the size of the process pipe is different from that for which the flowmeter was calibrated, solve the equation for both of the flow rate limits.

Example:

A 4-20 mA output signal was calibrated for a flow range of 3 to 30 ACFM (actual cubic feet per minute) with a 6" schedule 40 process pipe. The Flowmeter is to be installed in a 6" schedule 80 process pipe. What is the adjusted volumetric flow for outputs of 4 mA and 20 mA.

Given: An = 26.067 sq. in.; Ac = 28.89 sq.in.

Solution: Vc at 4 mA = 3 ACFM, therefore
Vn at 4 mA = 3 ACFM x 26.067 / 28.89
= 2.706 ACFM

Vc at 20 mA = 30 ACFM, therefore
Vn at 20 mA = 30 ACFM x 26.067 / 28.89
= 27.068 ACFM

Thus, volumetric flow rates between 2.7 and 27 ACFM can be measured in the 6" schedule 80 process pipe. If you are only interested in flow rates between 3 and 20 ACFM, then you could follow the procedure "Adjusting the Output Signal for a Different Flow Range" to increase output sensitivity.

Hint: Draw a graph of output current versus flow rate making a straight line between the two end points (2.7 ACFM at 4 mA and 27 ACFM at 20 mA) to use in the adjustment procedure.

VERIFICATION OF THE TEMPERATURE COMPENSATION

The Mass Flowmeter temperature compensation option rarely requires adjustment after it leaves the factory. You must be able to accurately control both the process medium temperature and flow rate in order to verify or calibrate the temperature compensation.

1. Turn on power and initiate a known flow rate at approximately 80% of the maximum flow rate at the low-limit temperature.

2. Allow the flowmeter signal to stabilize and record the output signal level.

3. Increase the temperature to the high limit while maintaining the same mass flow rate as established in Step 1.

4. Allow the flowmeter to stabilize and measure the output signal level. Verify that this flow measurement is within tolerance of the level recorded in Step 2.

If the flow rate measurement is not within the desired tolerance, review the appropriate calibration procedure as described below to ensure that you have the capability to improve the compensation.

CALIBRATION OF THE TEMPERATURE COMPENSATION

Turn off power. Open the electronic housing and remove the piggy-back boards until only the main circuit board remains. Use layout drawing in Appendix "B" to locate U17 and J9 on the main board.

i) If U17 is present, then perform the "Temperature Compensation".

ii) Otherwise if J29 is installed (but not J9), the flowmeter does not have temperature compensation circuitry. Therefore, re-assemble the board stack and secure the electronic housing.

TEMPERATURE COMPENSATION PROCEDURE

1. Carefully remove U17 from the IC socket. Install a 24 AWG jumper wire between pins 1 and 2 of the socket.

2. Turn power on and initiate a known flow at 80% of the maximum flow rate in SCFM, at the low-limit temperature. Allow the signal to stabilize.

3. Connect a DVM between pins 6 (+) and 7 (-) of the test plug "P1" (plug where the linearizer connects). Record this voltage.

4. Turn power off. Remove the jumper from the U17 socket and install the IC. Turn power on.

5. Initiate the same flow at the same temperature as in Step 2. Allow the signal to stabilize.

6. Adjust R45, LOG LOW, on the main board to yield the same Pin-6 voltage as found in Step 3, +/- 10 mV.

7. Increase the temperature to the high limit while maintaining the same mass flow rate in SCFM. Allow the signal to stabilize.

8. If necessary, adjust potentiometer R35, LOG HI, on the main circuit board for the voltage recorded in Step 3 +/- 20 mV.

9. Turn power off. Remove the jumper and replace U17. Remove the DVM and reassemble the board stack. Secure the electronic housing. The temperature calibration is now complete.

VERIFICATION AND CALIBRATION OF THE LINEARIZATION CIRCUIT

The flowmeter's linearization circuit rarely requires adjustment after it leaves the factory. When a Flowmeter is to be used outside the flow range for which it was calibrated, it is generally necessary to return it to FCI for re-calibration. Time, patience, and accurate equipment are required to properly calibrate the linearization circuit.

VERIFICATION OF THE LINEARIZATION CIRCUIT

Verification of the linearization circuit can be easily accomplished over the calibrated flow range using the Delta "R" Table for the flowmeter to be verified. You will need one or two DVMs accurate to 1 mV on the 5 Vdc range. Use Figure 2-24 to locate the CAL SWT, SW1, and CAL POT, R38, on the main circuit board.

1. Connect the positive lead of one DVM to pin 6 (Vin) of the test plug, the positive lead of the other DVM to pin 5 (Vout) of the test plug, and both negative leads to pin 7 (ground). If only one DVM is available, you will need to move the positive lead between Vin and Vout.

2. Move SW1, CAL SWT, on the main board away from the transformer and turn power on.

3. Adjust R38, CAL POT, until Vin is equal to the first value recorded in the Delta "R" table.

4. Measure Vout and verify that is within 5 mV of the value recorded in the Delta "R" Table.

5. Repeat Steps 3 and 4 for each set of values recorded in the Delta "R" Table.

6. When only a few values are slightly out of tolerance, you may want to try making a minor adjustment of the linearizer as follows rather than a complete calibration.

   a. Set Vin the lowest value for which Vout is out of tolerance using the CAL POT.

   b. Sequentially check the voltage at test points TP1, through TP8 on the linearizer board (refer to Figure 2-24) until you locate the first test point to have a negative voltage.

   c. Back up one test point and locate the slope potentiometer associated with that test point. (Slope pots R11 through R18 correspond to test points TP1 through TP8, respectively. For example, the slope pot for TP4 is R14).

d. Adjust this slope pot just enough to bring Vout within tolerance of the Delta "R" Table value.

e. Continue to sequence through increasing Vin values in the Delta "R" Table checking the Vout voltage. Repeat Steps b through d for each Vout which is still out of tolerance.

f. Repeat the verification procedure Steps 1 to 5.

NOTE: Remember a need to make anything but a minor adjustment is generally an indication of some other problem.

SENSOR CALIBRATION

The sensing elements of the FCI Mass Flowmeters do not require calibration. Careful performance of the electrical calibration described in the previous section of this manual is all that is generally required. However, if you still feel the flowmeter is giving erroneous readings perform the following checks.

1. Turn off the power to the Flowmeter.

2. Disconnect the wires from the Sensor Probe Assembly at the terminal strip TS2. Use an ohm meter to measure the resistance of the active and reference RTDs. If the instrument has been on for some time the resistance of the active RTD will be greater than the reference by approximately 100 ohms. Both RTD resistances should be approximately 1000 ohms. The resistance of the heater should be approximately 220 ohms.

3. Connect the wires from the probe to terminals ACT EXC, ACT SEN, REF EXC, REF SEN, GND, and GND SEN. Leave the heater disconnected.

4. Remove the probe from the process medium, observing the necessary precautions based on your application. Examine the sensing elements for visible build-up or deposit of material. Use a solvent compatible with your process medium and a bristle brush to scrub off any build-up. The solvent must not be corrosive to stainless steel.

5. Perform either step 5a or 5b depending on the circumstances (step 5a is preferred).

   a. Reinstall the probe and initiate flow. This flow should be near maximum of the calibrated range.

   b. Immerse the probe tip in water for 10 minutes to ensure that the active and reference sensors are at the same temperature.

CAUTION: Damage due to moisture penetration of the sensor or electronic assembly is not covered by the product warranty.

6. Connect a DVM between pins 6 (+) and 12 (-) of the test connector and turn on power.

7. Verify that the DVM reads 0 Vdc +/- 5 mV. If necessary, R32 SENSOR CURRENT BALANCE on the main circuit board may be adjusted to balance the sensor currents. If adjustment is necessary, then perform the Flowmeter Verification Procedure.

8. Turn off power. Connect the wires from the probe to the "HTR+" + and "HTR-" terminals on the main board. Re-install the probe if necessary.

9. If neither the Flowmeter Verification Procedure or these checks provide any symptoms of failure, then check to make certain that the wiring from the probe to the main circuit board is correctly installed and not broken or shorted.

NOTE: Flowmeters having remote electronics must have SEPARATE "SEN" and "EXC" wire from the Sensor Probe Assembly to the main circuit board for both the active and reference sensors in order to function properly. Refer to the "Electrical Wiring Installation" section.

CAUTION: The LT81A and LT87 Mass Flowmeter output signal, ("OUT+" and "OUT-"), CANNOT BE GROUNDED. Grounding of this output signal will cause SEVERE DAMAGE to the circuit board.

NOTE: When the sensor probe is connected to the electronics by remote cable, the cable shield is ONLY connected to the circuit board (TS2 "GND" terminal).

10. To check the wiring integrity of Flowmeters having remote electronics, make the voltage checks given at the beginning of the "Trouble Shooting" section. And if possible verify the following voltage relationships at BOTH the main circuit board and the terminal strip at the sensor probe assembly under normal operation conditions. Use a digital voltmeter to make the measurements.

(+) Lead	(-) Lead	Reading
ACT SEN	REF SEN	Greater than 0 Vdc
HTR EXC	HTR RTN	+ 16.5 Vdc
ACT EXC	ACT SEN	Greater than or = 0 Vdc
REF EXC	REF SEN	Greater than or = 0 Vdc

To verify that ACT EXC and REF EXC have not been accidentally reversed, disconnect the ACT EXC and ACT SEN wires. Measure the resistance between them. It should be equal to the resistance of the two wires. Values of 200 ohms or more indicate that wires have been reversed.

NOTES:

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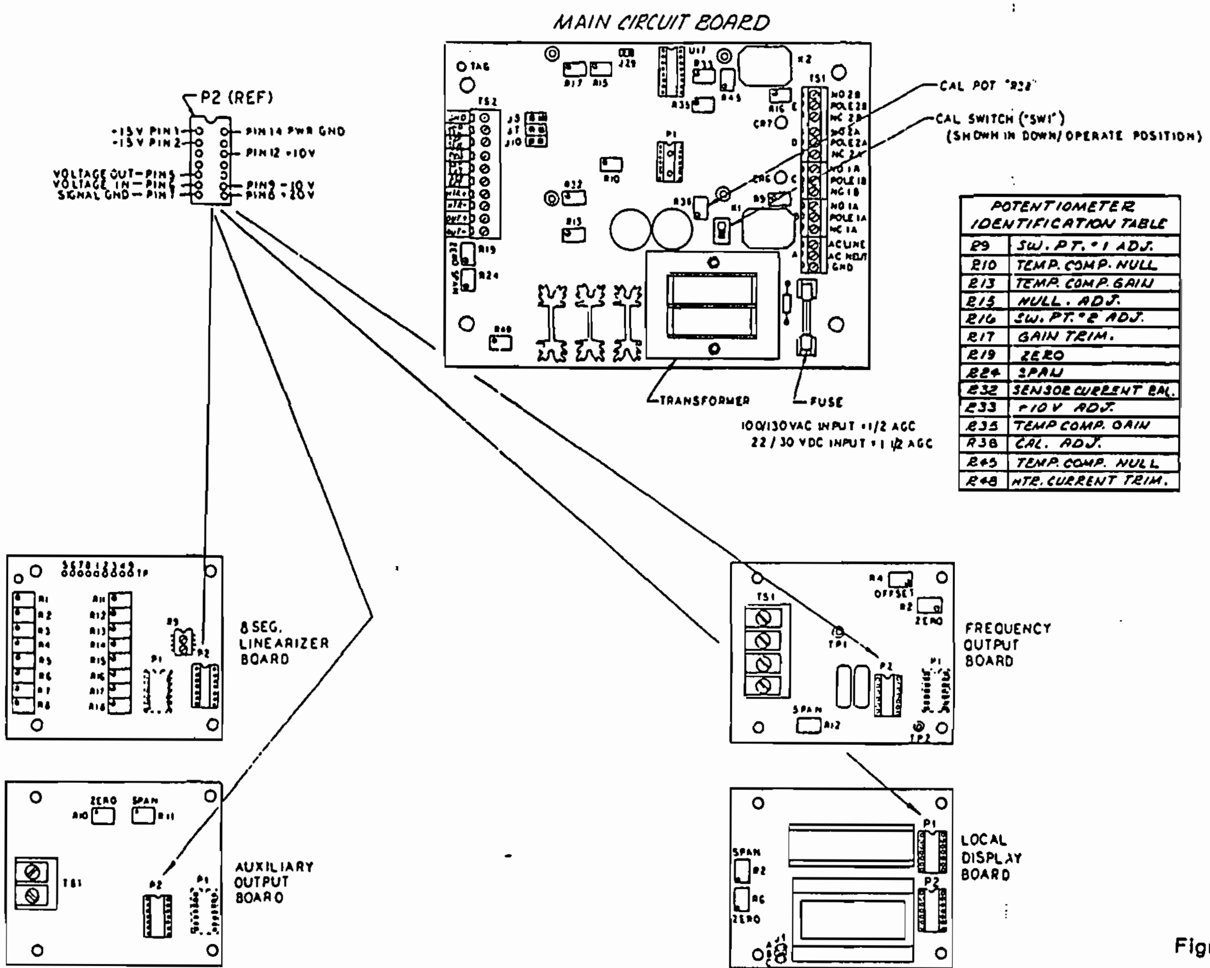

POTENTIOMETER IDENTIFICATION TABLE	
R9	SW. PT. #1 ADJ.
R10	TEMP. COMP. NULL
R13	TEMP. COMP. GAIN
R15	NULL. ADJ.
R16	SW. PT. #2 ADJ.
R17	GAIN TRIM.
R19	ZERO
R24	SPAN
R32	SENSOR CURRENT BAL.
R33	+10 V ADJ.
R35	TEMP COMP. GAIN
R38	CAL. ADJ.
R45	TEMP. COMP. NULL
R48	HTR. CURRENT TRIM.

Figure 2-24
Simplified Circuit Board Layouts

NOTES: UNLESS OTHERWISE SPECIFIED

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THEORY OF OPERATION

OPERATING PRINCIPLES

The design of FCI Mass Flowmeters results in a direct measurement of mass flow rate. Two RTDs (resistance temperature detectors) are used as the Active and Reference sensors for the flow rate detector using the thermal dispersion principle. FCI has found that the platinum RTDs track each other very closely over the operating range of the Mass Flowmeter.

The preferential heating of the Active sensor results in a temperature differential between it and the unheated Reference sensor which is greatest at no flow. As the molecules of the moving medium bump into the sensing elements, they absorb and take with them some of the heat. At increased flow rates more molecules contact the elements thereby absorbing more of the heat. At some upper flow rate limit enough heat is being absorbed so that the temperature differential becomes negligible. This upper limit has been found to be above 200 f/s in air at standard conditions. Standard conditions at FCI are defined as 70 degrees (F) and 14.7 PSIA.

Because the temperature differential depends on the number of gas molecules colliding with the sensing elements, the effects of pressure changes in the medium are automatically taken into account in the mass flow rate (the greater the pressure the greater the number of molecules). FCI has found that the effect of a temperature change on mass flow rate for a particular gas is not constant over the entire flow range. See Figure 3-1.

A temperature calibration is available for Mass Flowmeters operating in applications where the process temperature spans 30 degrees (F) or more.

A constant current is supplied across each of the RTDs. Because the temperature differential between the two matched RTDs results in a difference in resistance, the difference in voltage drop across the two RTDs is a direct measurement of the temperature differential.

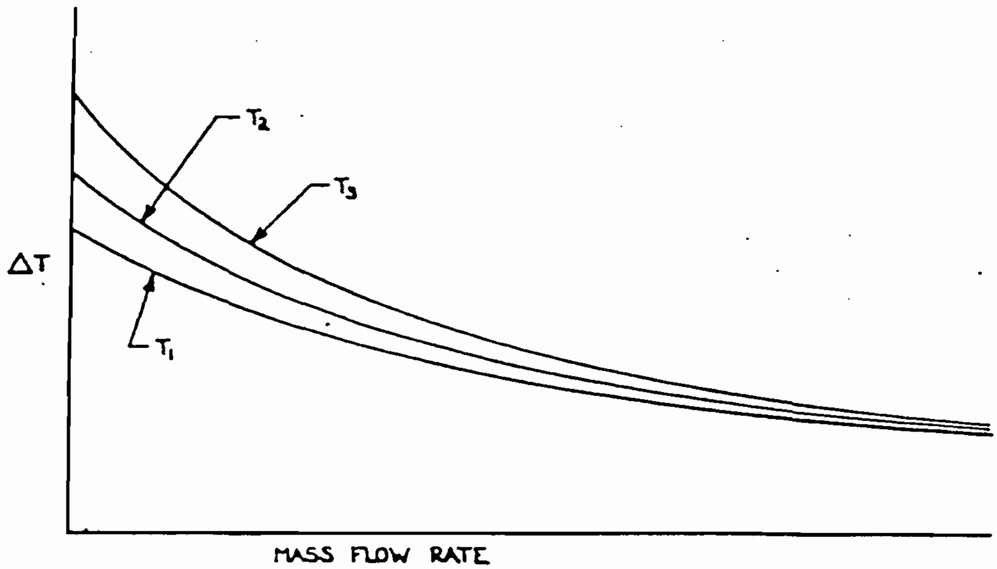


FIGURE 3-1
Changes in Process Temperature

The resistance of a wire is proportional to its length. Therefore, in flowmeters where the electronics are remote from the sensor probe, it becomes necessary to use a form of "Kelvin Sensing" to measure the voltage drop across the RTDs in order to eliminate errors resulting from the voltage drop in the remote cables.

As shown in Figure 3-2, one set of wires supplies the constant current through the resistor (RTD). A separate set of wires is used to measure the voltage drop across the resistor. Because no current flows through the pair of wires used to measure the voltage, the resistance of the wires does not affect the voltage measured. In the Mass Flowmeter, ACT EXC and GND, and REF EXC and GND form the current carrying pair of wires for the two RTDs. The voltage sensing pair consist of ACT SEN and GND SEN for the active sensor, or REF SEN and GND SEN for the reference sensor. The sense wires are connected to the inputs of a differential amplifier and therefore carry almost no current. This keeps the differences in wire resistance negligible for long runs from the Sensor Probe Assembly to the Electronic Assembly.

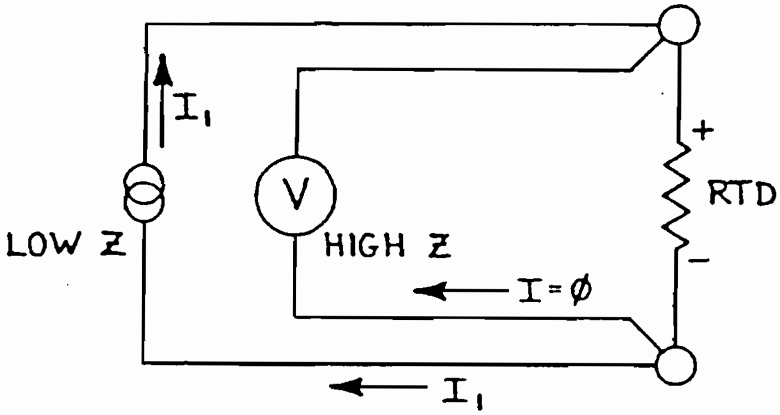


FIGURE 3-2
KELVIN SENSING

CIRCUIT DESCRIPTIONS

Before attempting to repair a Mass Flowmeter, carefully review this section which describes the circuits in terms of a functional block diagram. Only persons with training in electronic circuits should attempt repair of the circuit boards.

NOTE: Replacement of certain parts will invalidate the Flowmeter calibration and require a complete recalibration by the FCI Test Department. Refer to the "Functional Discussion of the Main Flowmeter Circuit Board" for which parts may not be replaced.

WARNING: Turn off power before removing or installing a circuit board or a component on a circuit board. The operator assumes all responsibility for conformance to safety standards and practices when using electric current.

When component replacement is necessary, a qualified technician should complete the "Flowmeter Verification Procedure" contained in this manual. When replacing components, be sure to use the same part type and number (pin compatible operational amplifiers are not acceptable).

NOTE: Damage to the circuit boards caused by part replacement is not covered by the product warranty.

FUNCTIONAL DISCUSSION OF THE MAIN CIRCUIT BOARD

Figure 3-3 is a functional block diagram of the main flowmeter circuit board. The standard flowmeter has regulated +/-15 Vdc and +20 Vdc power supplies. The +20 Vdc supply is formed by referencing a 5 Vdc regulator to the +15 Vdc supply. In addition, a +10 Vdc reference and a differential amplifier are used to provide a low current +/- 10 Vdc supply. The +10 Vdc reference is used by the three constant current sources. There is a constant current source for the heater and one for each of the RTD sensors.

The voltage drop created by the constant current supplied to each sensor provides the input to a differential amplification circuit. With the current being constant, the voltage drop is directly proportional to the resistance. The output of this circuit is a Delta "V" signal representing the Mass Flow Rate. An additional differential amplification circuit monitors the voltage drop across the reference sensor. The output of the reference sensing amplifier is used to correct for the effect of changes in the process temperature.

Since the Delta "V" signal decreases exponentially with increasing Mass Flow, it is inverted and offset +10 Vdc before being fed to the linearization circuit. The linearizer uses an eight segment piecewise correction.

Each segment of the linearizer circuit becomes effective at a different breakpoint voltage. All eight segments are connected to the input of a summing amplifier. The output of this amplifier is a voltage representing the linearized Mass Flow Rate. A calibrated step voltage can also be input to the summing amplifier to allow for a "Zero Based" flow rate versus output signal curve.

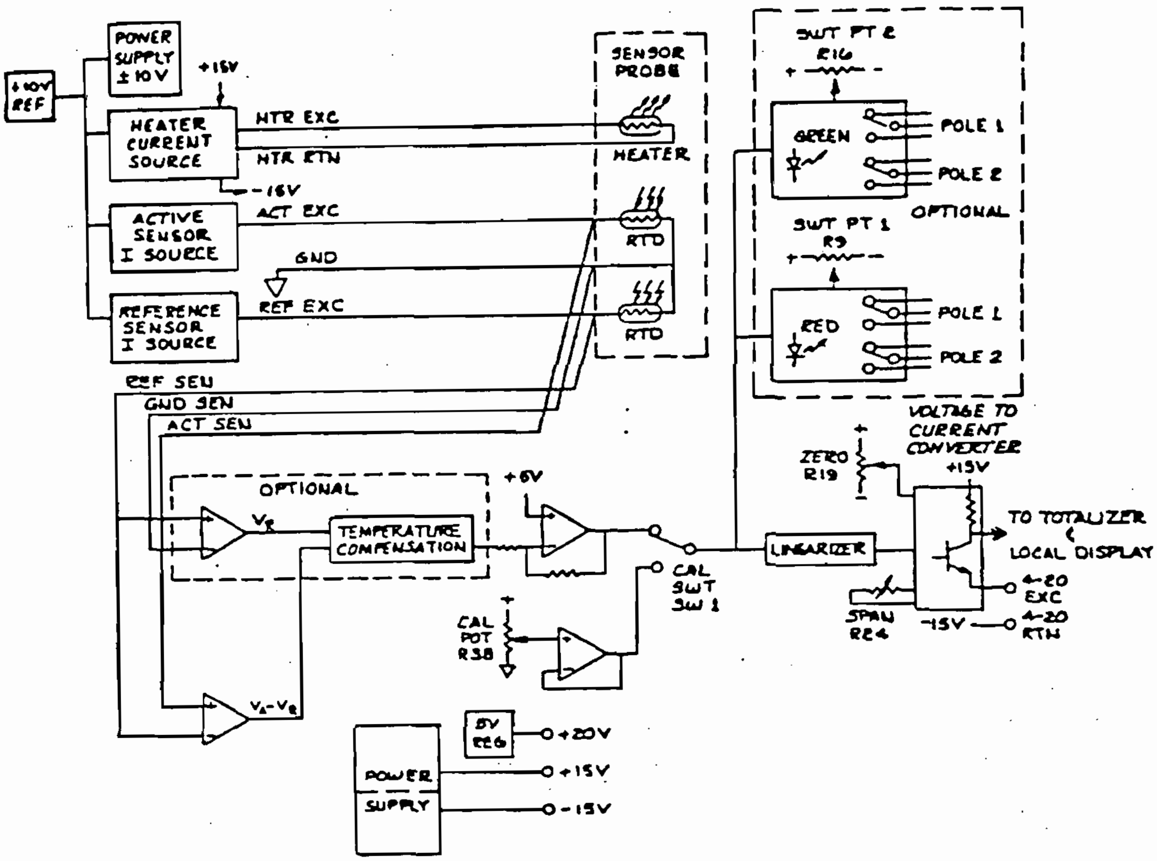


FIGURE 3-3
Main Circuit Board Block Diagram

Zero based means; if the line representing the flow rate versus output is extended, it will pass through the origin (zero). The step voltage segment causes the output signal to remain zero until the low-limit flow rate is reached, and then it steps to the correct signal level. The output of the linearization circuit is fed to a voltage amplifier whose gain and offset can be adjusted to provide the correct Zero and Span for the output signal. When the output signal is to be a current loop, this voltage provides the input signal for the voltage to current converter.

The operating signal for the optional switch point relay(s) is the same Delta "V" signal as the input to the linearization circuit. The circuit for each switch point is the same except for the color of the LED which indicate relay activation (activation occurs when the flow rate exceeds the switch point setting. There is a plugable jumper which determines whether the relay is energized or de-energized at "No Flow" (flow rates below the switch point setting). The operational amplifiers in the switch point circuitry are being used as voltage comparators. The outputs will be nearly equal to one of the supply voltages depending on whether the present flow rate signal exceeds the switch point setting or not.

FUNCTION DISCUSSION OF THE FREQUENCY OUTPUT BOARD AND TOTALIZER

Figure 3-4 is the block diagram for the totalizer option. The input to the frequency board is the voltage dropped across the sensing resistor of the current converter on the main circuit board. This voltage drop is referenced to the +15 Vdc supply. The voltage drop is buffered to prevent loading of the output signal source, then inverted and referenced to ground. The ZERO and SPAN pots on the frequency output board allow the voltage applied to the voltage-to-frequency converter to be adjusted so that the output frequency is correct for both the low and high flow rate voltages. The lower the input voltage is to the converter the lower the frequency of the output pulse.

The OFFSET pot is used to disable the voltage-to-frequency converter when the flow rate drops below the low-limit flow rate for which the flowmeter was calibrated. This prevents the totalizer from accumulating false counts under drift conditions. The voltage-to-frequency converter is disabled when its "sync" line or pin 2 is equal to the plus supply voltage.

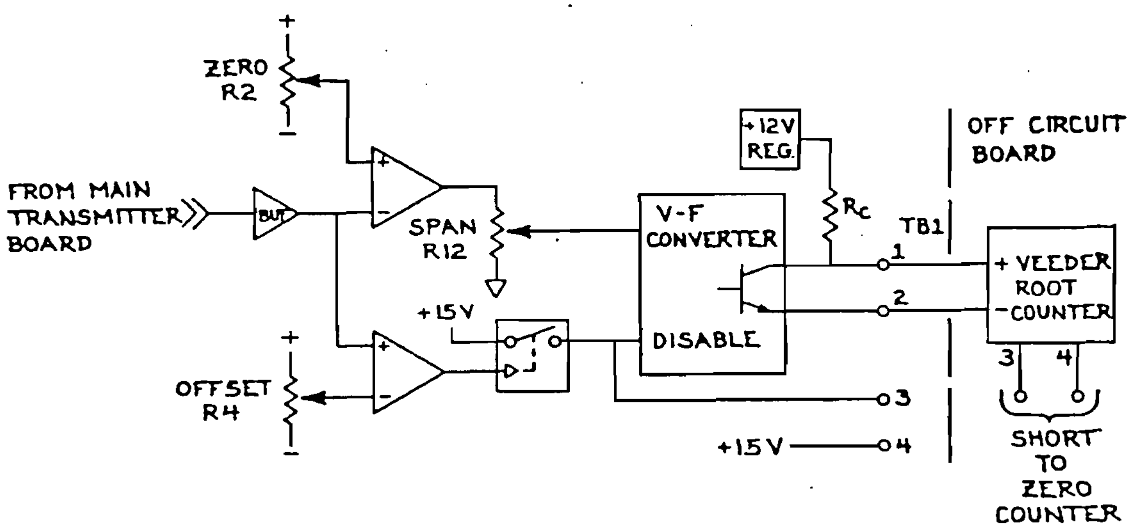


FIGURE 3-4
Totalizer Block Diagram

A +12 Vdc regulator is used to supply the pull-up resistor for the open collector output of the voltage-to-frequency converter. Using a separate regulator for this pull-up resistor isolates the +15 Vdc supply from the switching noise of the converter output.

The output from the voltage to frequency converter is the input signal for the Veeder Root Electronic Counter. Shorting pins 3 and 4 of the Veeder Root Counter resets the eight digit Liquid Crystal Display Readout to zero.

FUNCTIONAL DISCUSSION OF THE LOCAL DISPLAY BOARD

Figure 3-5 is the block diagram for the local display board. The input to the local display board is the voltage dropped across the sensing resistor of the current converter on the main circuit board. This voltage drop is referenced to the +15 Vdc supply. The voltage drop is buffered to prevent loading of the output signal source, then inverted and referenced to ground.

The ZERO and SPAN pots on the display board allow adjustment of the voltage fed to the A/D converter such that the display reads correctly at both the low and high limit flow rate. The A/D converter also contains the necessary drive circuits for the 3 1/2 digit Liquid Crystal Display. The drive current for the decimal point is provided by the FET. The position of the decimal point is determined by the position of the jumper as indicated on the schematic located in Appendix "B".

The +/- 5 Vdc regulators on the display board provide the proper supply voltages for the A/D converter. The sample rate of the A/D is set by the "RC" network across pins 2 and 3. The components used in the LT81A and LT87 provide about 2.5 readings per second.

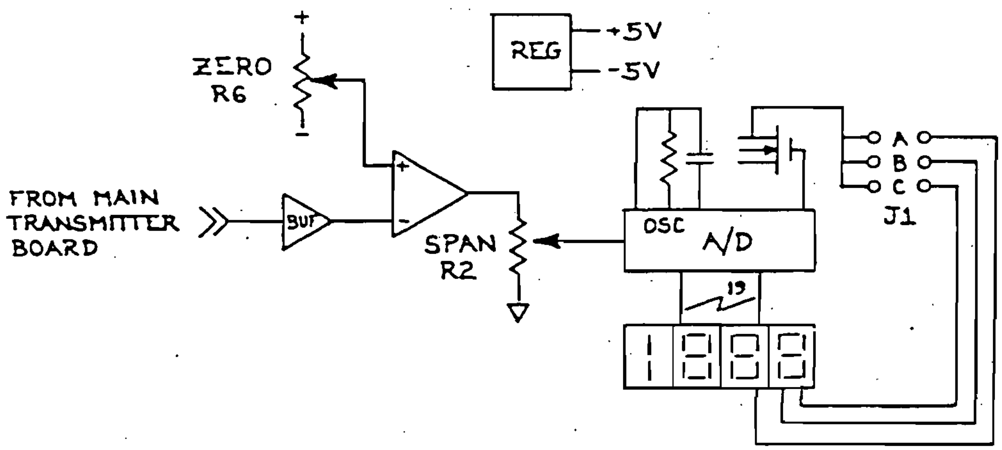


FIGURE 3-5
Local Display Block Diagram

TROUBLE SHOOTING

Only personnel with proper training should attempt to repair FCI Mass Flowmeters. Replacement parts must be of the same part type and number (pin compatible operational amplifiers are not acceptable). Damage to the circuit boards caused by part replacement is not covered by the product warranty. When parts are replaced, the "Flowmeter Verification Procedure" should be performed by a qualified technician to ensure proper operation of the flowmeter.

CAUTION: The operator assumes all reponsibility for conformance to safety standards and practices when trouble shooting. Damage to the flowmeter caused by operator negligence is not covered by the product warranty.

Good trouble shooting technique requires that you observe as many symptoms of failure as possible before attempting repair. For example, if a flowmeter having both the local display and totalizer options is observed not to be accumulating the proper units, you should check both the local display and the output signal to determine if the medium is flowing as expected. The primary power supply for all the circuit boards is located on the main circuit board; the power supply is a prime candidate when there appears to be multiple failures in the flowmeter.

In new installations or recently calibrated flowmeters, operating problems are most often caused by improper installation. Review the section on "Sensor Assembly Installation" to verify correct mechanical installation. It is essential for proper operation of the flowmeter that separate "sense" (SEN) and "excitation" (EXC) wires be provided in flowmeter with remote Electronic Assemblies. Also, reversing the "ACT" and the "REF" wires will cause the flowmeter to output incorrect flow rates.

NOTE: The resistance of the Active RTD is greater than the resistance of the Reference RTD whenever the heater is running and the flow rate is below the high-limit flow.

CAUTION: The LT81A and LT87 output signal, ("OUT+" and "OUT-"), CANNOT BE GROUNDED. Grounding of this output signal will cause SEVERE DAMAGE to the circuit board.

REPAIR AND MAINTENANCE

NOTE: When the Sensor Probe Assembly is connected to the Electronic Assembly by a remote cable, the cable shield is ONLY connected at the Electronic Assembly on Terminal Strip TS2 "GND" terminal.

The following voltage checks are to be performed with power applied to the flowmeter under normal operating conditions. These voltage checks will verify correct wiring and general integrity of the flowmeter. All measurements should be made using a digital voltmeter with differential (non-grounded) input.

MEASUREMENT MADE ALONG THE MAIN BOARD TERMINAL STRIPS

(+) Lead	(-) Lead	Reading
AC HI	AC LO	115 Vac
4-20 RTN	GND	-15 Vdc
HTR EXC	HTR RTN	+16.5 Vdc
REF SEN	GND SEN	+ 1.100 Vdc (approx.) * (at room temperature)
ACT SEN	GND SEN	+ 1.200 Vdc (approx.) ** (at room temperature)
ACT SEN	REF SEN	+ 0.100 Vdc (approx.) *** (at room temperature)

* More Exactly: (1.00+.0375T)VDC; Where: T=Ambient Temperature (Deg. C)

** More Exactly: (Vrs-Vgs)+(Vas-Vrs)

*** More Exactly: .001 X Delta "R"

MEASUREMENTS MADE AT THE
TEST PLUG ON THE TOP BOARD

(+) Lead	(-) Lead	Reading
Pin 1	Pin 14	+15 Vdc
Pin 2	Pin 14	-15 Vdc
Pin 8	Pin 14	+20 Vdc
Pin 9	Pin 14	-10 Vdc
Pin 12	Pin 14	+10 Vdc

If all these voltage checks are correct, then the next section, "Using the Delta R Table", should help you in determining the problem.

USING THE DELTA "R" TABLE

The Delta "R" Table contains a great deal of useful information. It can be used to verify the correct operation of electronics independent of the Sensor Probe Assembly by simulating the sensor RTDs with accurate resistance decades. Even when resistance decades are not available, proper operation of the linearizer and current converter circuits can be verified using the calibration test signal available at Switch SW1 on the main circuit board. This same procedure can be used to return the output signal to the factory calibrated values whenever the flow range has been adjusted as described in "Adjusting the Output Signal for a Different Flow Range".

To simulate the sensor RTDs, turn off power and replace the RTDs with a decade and precision resistor as described in the beginning of the "Flowmeter Verification Procedure" given in Chapter 2 of this manual. Increase the "Active" decade resistance by the Delta "R" values listed in the table for your flowmeter. Read the voltage at pin 6 of the test plug "P1" (pin 7 is ground) and compare to the "Voltage In" listed in the table. "Voltage In" is the output of the front end circuitry of the flowmeter and the input to the linearization circuit. The measured voltage should be within 10 mV of the recorded value, provided the DVM used to measure the voltage is accurate to 1 mV and the decades (and/or resistor) are accurate within 0.1%.

If a resistance decade is not available, then place SW1, CAL SWT, on the main circuit board in its calibrate position (away from the transformer). You can now use the CAL POT, R38, on the main board to set the "Voltage In" values listed in the Delta "R" table. By doing this you can verify proper operation of the linearizer and the current converter circuits, but not the front-end circuitry.

Measure the "Voltage Out" (voltage at pin 5 of the test plug) and compare to the value listed in the table for the corresponding "Voltage In" (set either by increasing the resistance of the active decade or by varying the CAL POT). "Voltage Out" is the output of the linearizer circuit and will typically measure within 20 mV of the recorded value with properly calibrated equipment.

The output of the current converter is recorded in the Delta "R" Table in the "Output Signal" column. For current loop outputs replace the output load with a milliammeter. (Turn off power and connect the positive lead to the "OUT+" terminal on the main board and the negative lead to "OUT-" terminal.) The measured current should match the recorded current within 0.5 mA provided the milliammeter is accurate to 0.1 mA and the "Voltage Out" is equal to the value in the table. For voltage outputs, connect a DVM across the output load (terminals "OUT+" and "OUT-" on the main circuit board). The measured voltage should match the recorded output signal within 125 mV.

To return the current converter to its factory calibration, use CAL POT, R38, to set the pin 5 voltage equal to the low flow value (lowest output signal) given in the Delta "R" Table. (Note the CAL SWT must be away from the transformer for the CAL POT to function.) Adjust R19, ZERO, on the main board until the output signal meter reads the value shown in the table. Use the CAL POT to set the pin 5 voltage to the high flow value in the table and adjust R24, SPAN, on the main board until the output signal meter reads the corresponding value in the table. Alternate between these two pin 5 voltages and signal adjustments until both are within 2% of the high-limit signal value.

Turn off power and replace the output load. The output signal is now back to its factory calibrated value. Return the CAL SWT to the "OP", operating position (toward the transformer). If you replaced the sensors with resistors, then remove the resistors and reconnect the Sensor Probe Assembly cable.

TROUBLE SHOOTING OPERATION AMPLIFIERS

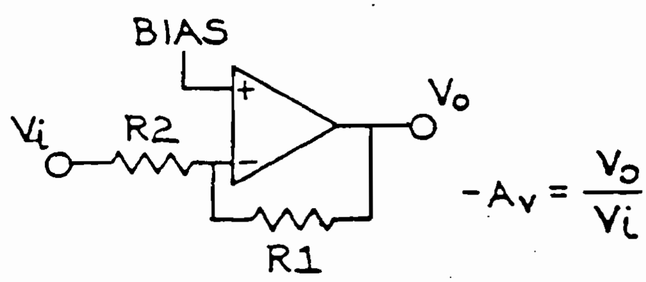
The following tips are provided to assist the experienced electronic technician in determining when an operation amplifier has failed. In nearly all cases, a voltage difference greater than 250 micro volts between the inputs to the amplifier results in the output being within a volt or two of one of the supply voltages. The output should be near the plus supply when the plus input is more positive than the negative input. Figure 3-6 shows the gain formula for both an inverting and non-inverting amplifier.

MAINTENANCE

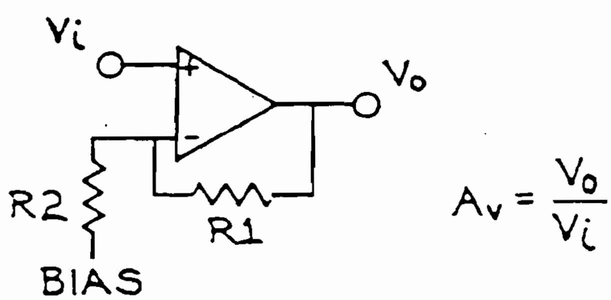
Regularly scheduled maintenance and calibration checks will ensure that the Flowmeter can provide accurate flow measurements over a long period of time. In addition to the verification and calibration procedures described in this manual, you will need to make periodic checks of all O-rings, gaskets, moisture seals, environmental seals, etc. It is important to remove and lubricate or replace seals in conformance with the application requirements.

CAUTION: Damage resulting from moisture penetration of the sensor or electronic assembly is not covered by the product warranty.

CAUTION: To avoid hazards to personnel, ensure that all environmental isolation seals are properly maintained.



Av = R1/R2
Inverting Amplifier



Av = 1 + R1/R2
Non-inverting Amplifier

FIGURE 3-6
Operational Amplifier Gain

INSTALLING REPLACEMENT CIRCUIT BOARDS

Replacement circuit boards can be ordered from FCI and installed with minimal adjustments. After the replacement boards have been physically installed, make the following adjustments:

MAIN CIRCUIT BOARD

1. Disconnect "HTR+" lead to sensor head.
2. Perform either step 2a or 2b depending on circumstances (step 2a is preferred).
   a. With probe installed, initiate a flow near the high end of the calibrated range.
   b. Remove the probe and immerse its tip in ambient water for ten minutes to ensure that the active and reference sensors are at the same temperature.
3. Connect a DVM between pin 6 (+) and pin 12 (-) of the test connector and turn on power.
4. Verify that the DVM reads 0 Vdc +/- 5 mV. Adjust R32, sensor current balance, if necessary to zero this voltage. Re-install probe if necessary and reconnect "HTR+".

LINEARIZER BOARD

1. No adjustments necessary.

FREQUENCY OUTPUT BOARD

1. Perform totalizer calibration procedure.

LOCAL DISPLAY BOARD

1. Perform local display calibration procedure.

APPENDIX A - PART NUMBER DECODING

The twelve character part number located on the main circuit board begins with 0017-. The remaining eight characters encode the option configuration of the Flowmeter. Figure A-1 shows the meaning of each character. In Figure A-1, the characters enclosed in square brackets indicate the sales literature callouts for the options. Check the part number carefully BEFORE installing the Flowmeter to be sure it has all the options you ordered.

The sales literature callouts for the environmental options are as follows:

OPTION	SALES CALLOUT
Special Coating	CC
Explosion Proof Housing	GCD
Epoxy Coated Housing	EH

0017- _ _ _ _ _ _ _ _

PART NO	INPUT POWER	DES
010558-01	115 VAC (100-130 VAC)	A
010559-01	230 VAC (200-270 VAC)	B
010560-01	24 VDC (22-30 VDC)	C
010677-01	100 VAC (90-100 VAC)	D

PART NO	HEATER POWER	DES
010561-01	1.41 WATT	1
010562-01	0.72 WATT	2
010563-01	0.60 WATT INTRINSIC SAFETY ONLY	3

PART NO	AMPLIFIER GAIN	DES
010565-01	X50	A
010566-01	X100	B
010614-01	X200	C
010615-01	X400	D
010616-01	X800	E

PART NO	SENSOR RESISTANCE	DES
010797-01	1000 Ω	1
010617-01	100 Ω	2

DES	△ SWITCHPOINT 2 △	PART NO
1	NONE	—
2	10 AMP ENERGIZED AT FLOW	010581-01
3	10 AMP ENERGIZED AT NO FLOW	010582-01
4	2 AMP ENERGIZED AT FLOW	010579-01
5	2 AMP ENERGIZED AT NO FLOW	010580-01

DES	SWITCH POINT 1	PART NO
A	NONE	—
B	10 AMP - ENERGIZED AT FLOW	010577-01
C	10 AMP - ENERGIZED AT NO FLOW	010578-01
D	2 AMP - ENERGIZED AT FLOW	010575-01
E	2 AMP - ENERGIZED AT NO FLOW	010576-01

DES	SIGNAL OUTPUT	PART NO
△ 1	4-20 mA	010570-01
△ 2	10-50 mA	010571-01
3	1-5 VDC	010572-01
4	0-5 VDC	010573-01
5	0-10 VDC	010574-01

DES	AUXILIARY CIRCUIT BD.	PART NO
A	NONE	000461-0[illegible]
B	8 SEG. LINEARIZER	010364-02
C	8 SEG. LINEARIZER [illegible]	010782-02
D	8 SEG LINEARIZER [illegible] OUTPUT 50 mA	010567-01
E	8 SEG LINEARIZER [illegible] OUTPUT 50 mA [illegible]	010368-01
△ F	4-20 mA (8 SEG LINEARIZER [illegible]) SIGNAL OUTPUT	010869-01
△ G	10-50 mA (8 SEG LINEARIZER [illegible])	010569-02

△ AMP RATINGS ON RELAYS ARE AT 115 VAC.

△ [illegible] IS A JUMPER [illegible] INDICATED FOR THIS OPTION.

△ AUX. C.B. BLOCK DES "F" TO BE USED WITH SIG. OUT. BLOCK "1" ONLY.

△ AUX. C.B. BLOCK DES "G" TO BE USED WITH SIG. OUT. BLOCK "2" ONLY.

△ SWITCH POINT "2" CANNOT BE USED WITHOUT SWITCH POINT "1".

APPENDIX B - SCHEMATICS AND LAYOUTS

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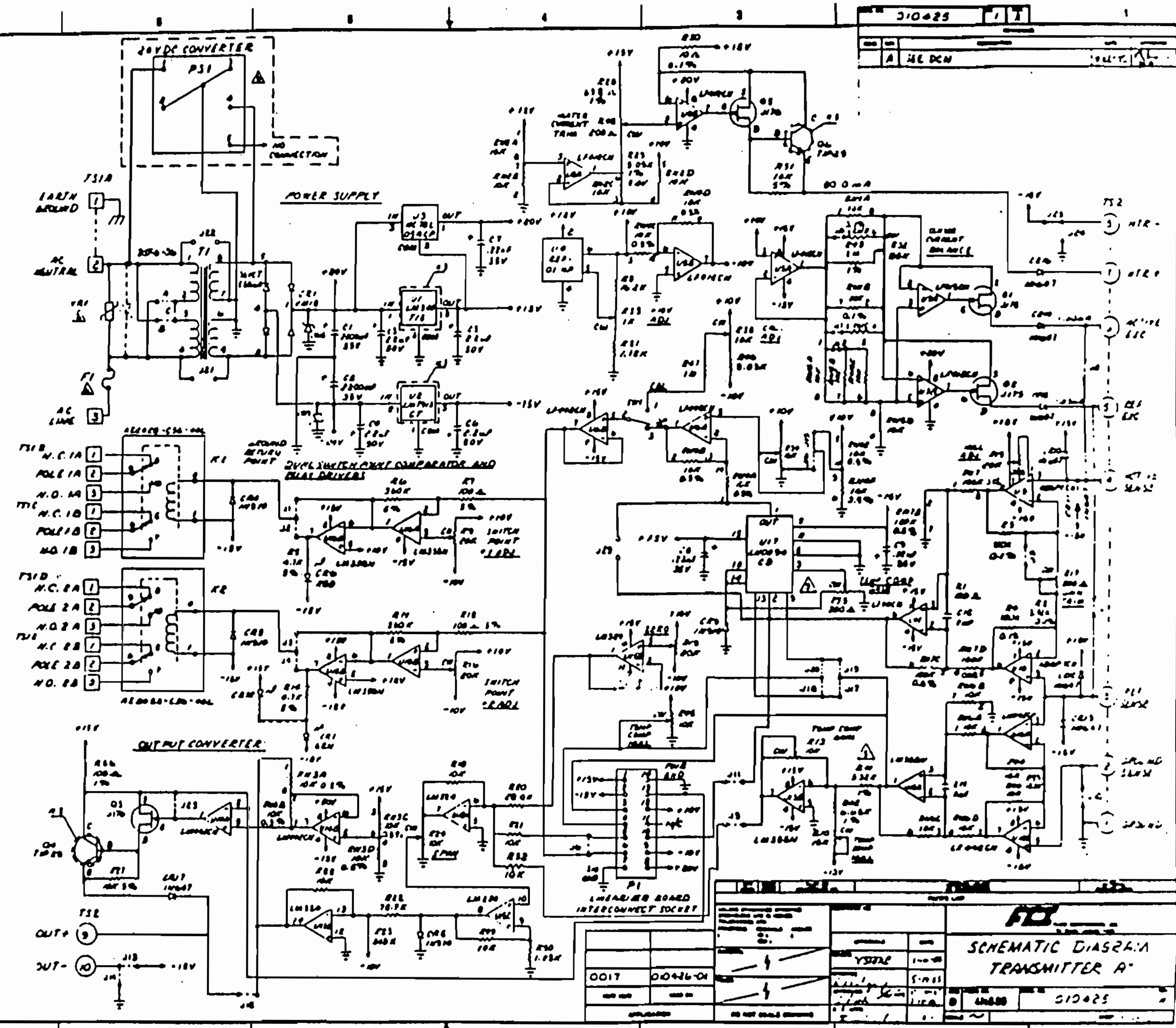

FOR NOTES SEE SHEET TWO.

1

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210425

1. INTRINSIC SAFETY
OMIT [illegible] INSTALL A JUMPER ON CR1[illegible], CR1[illegible] & CR1[illegible]. INSTALL JUMPER J[illegible]. INSTALL SHORTING PLUG ON [illegible] [illegible] HEATER MUST BE USED WITH THIS OPTION.

POWER INPUT
A) FOR 115 VAC OMIT PS1 INSTALL JUMPER A1B USE VARISTOR [illegible] FOR VR1. USE A [illegible] AMP FUSE FOR F1.
B) FOR 220 VAC - 240 VAC INPUT OMIT PS1 INSTALL JUMPER C USE VARISTOR [illegible] FOR VR1 USE A [illegible] AMP FUSE FOR F1.
C) FOR 24VDC - 24VDC OMIT T1, CR1, C4, [illegible] ADD JUMPERS JE2 & JE1. INSTALL A JUMPER FROM PIN 1 TO PIN 4 & PIN 2 TO PIN 3 OF CR1 INSTALL A JUMPER FROM THE INPUT OF U[illegible] TO THE OUTPUT OF U[illegible]. [illegible]
D) FOR 90-110 VAC INPUT, REPLACE "T1" DST-6-36 WITH DST6-48.

3. TEMP COMP
DRAWING SHOWS BOTH MULTIPLICATIVE AND ADDITIVE TEMP. COMPENSATION. TO DELETE MULTIPLICATIVE COMP. OMIT [illegible] R45, R56, J18 & J19 ADD A JUMPER FROM PIN 1 & PIN 2 OF U7. TO DELETE ADDITIVE COMP., OMIT R10, R13, R41, R48 AND J9.

4. INTEGRAL OR REMOTE
FOR INTEGRAL UNITS (NO SENSE LEADS) INSTALL J7, J8 [illegible] FOR REMOTE UNITS (WITH SENSE LEADS) OMIT J7, J8 AND J10.

3. LINEARIZATION
FOR USE WITH THE 8 SEGMENT LINEARIZER BD (NORMAL CONFIGURATION) INSTALL J11, J15 AND OMIT R34. FOR USE WITH THE 6 SEGMENT BD OMIT J11 AND J15 AND INSTALL R34.

2. OUTPUT SIGNAL
THE COMPONENT VALUES SHOWN ARE FOR 4-20 mA. VALUES FOR ALTERNATE CONFIGURATIONS ARE AS FOLLOWS. ON THE 10-50 mA OUTPUT OPTION, A HEATSINK IS REQUIRED ON Q4.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

1. HEATER POWER AND FRONT END GAIN
THE COMPONENT VALUES SHOWN ON THE FACE OF THE DRAWING ARE FOR THE MOST COMMON CONFIGURATION (1000 Ω SENSORS 1.82 W HEATER, GAIN OF 50, 4-20 mA OUTPUT) VALUES FOR ALTERNATE CONFIGURATIONS ARE AS FOLLOWS.

SENSOR RESISTANCE							
[illegible] TYPE	R41	R43	R38	Q1.2	J26	J27	J28
[illegible]	[illegible]	1.00K	[illegible]	[illegible]	IN	IN	OUT
[illegible]	[illegible]	402K	20K	[illegible]	OUT	OUT	IN

RESISTOR LISTED FOR R8, R3[illegible] ARE 0.1% 1/8 W 25 PPM/°C

NOTES: UNLESS OTHERWISE SPECIFIED

FRONT END AMP GAIN				
GAIN	R8	R7	R3.0	U3.10
160	392K	800 Ω	100K	400 7CH
200	1.44M	800 Ω	100K	
1200	976 Ω	50 Ω	100K	[illegible]
1400	475 Ω	50 Ω	100K	
1600	143 Ω	20 Ω	100K	

HEATER POWER			
HEATER WATTAGE	HEATER CURRENT	R20	HEATER RESISTANCE
0.12W	52.0 mA	475 Ω	221 Ω 1%
1.61W	80.0 mA	698 Ω	
0.60W	94 mA	806 Ω	[illegible] 1%

HEATER CURRENT VALUES HAVE AN ADJUSTABILITY OF ±12% WITH R[illegible] HEATER TRIM.

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11. RELAYS SHOWN ARE RATED AT 8 AMPS. 115VAC. FOR A RATING OF 10 AMPS 115 VAC USE [illegible]-C56-[illegible] OR EQUIVALENT. J1 & J2 CONTROL THE ENERGIZATION OF K1, J3 & J4 CONTROL THE ENERGIZATION OF K2. FOR A RELAY CONDITION ENERGIZED AT FLOW USE J1 FOR K1 AND J3 FOR K2. FOR A RELAY CONDITION ENERGIZED AT NO-FLOW USE J2 FOR K1. J4 FOR K2. RELAY CONTACTS ARE SHOWN WITH RELAYS DE-ENERGIZED.

10. RNP, 3.4.5.6.7 HAVE AN ABSOLUTE TOL. OF 0.5% AND A RATIO TOL. OF 0.1%.

9. RN1 HAS A ABSOLUTE TOL. OF 0.1% AND A RATIO TOL. OF 0.05%.

8. ALL RESISTORS ARE 1%. ALL 1% RESISTORS ARE 1/8W 50 PPM/°C. ALL 5% RESISTORS ARE 1/4W [illegible] PPM/°C UNLESS OTHERWISE NOTED.

FCI

SCHEMATIC DIAGRAM TRANSMITTER "A"

0017

210425

2

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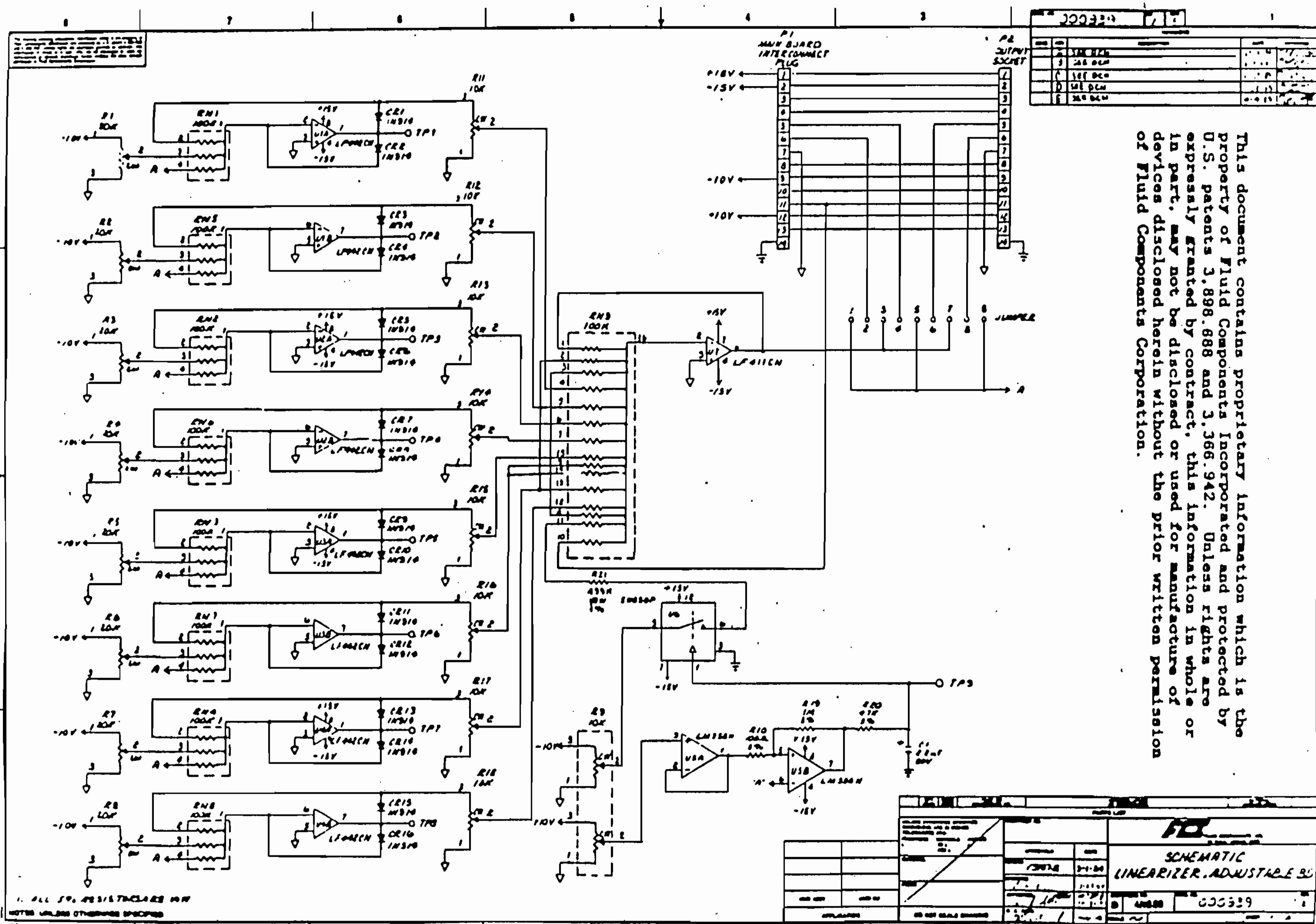

3

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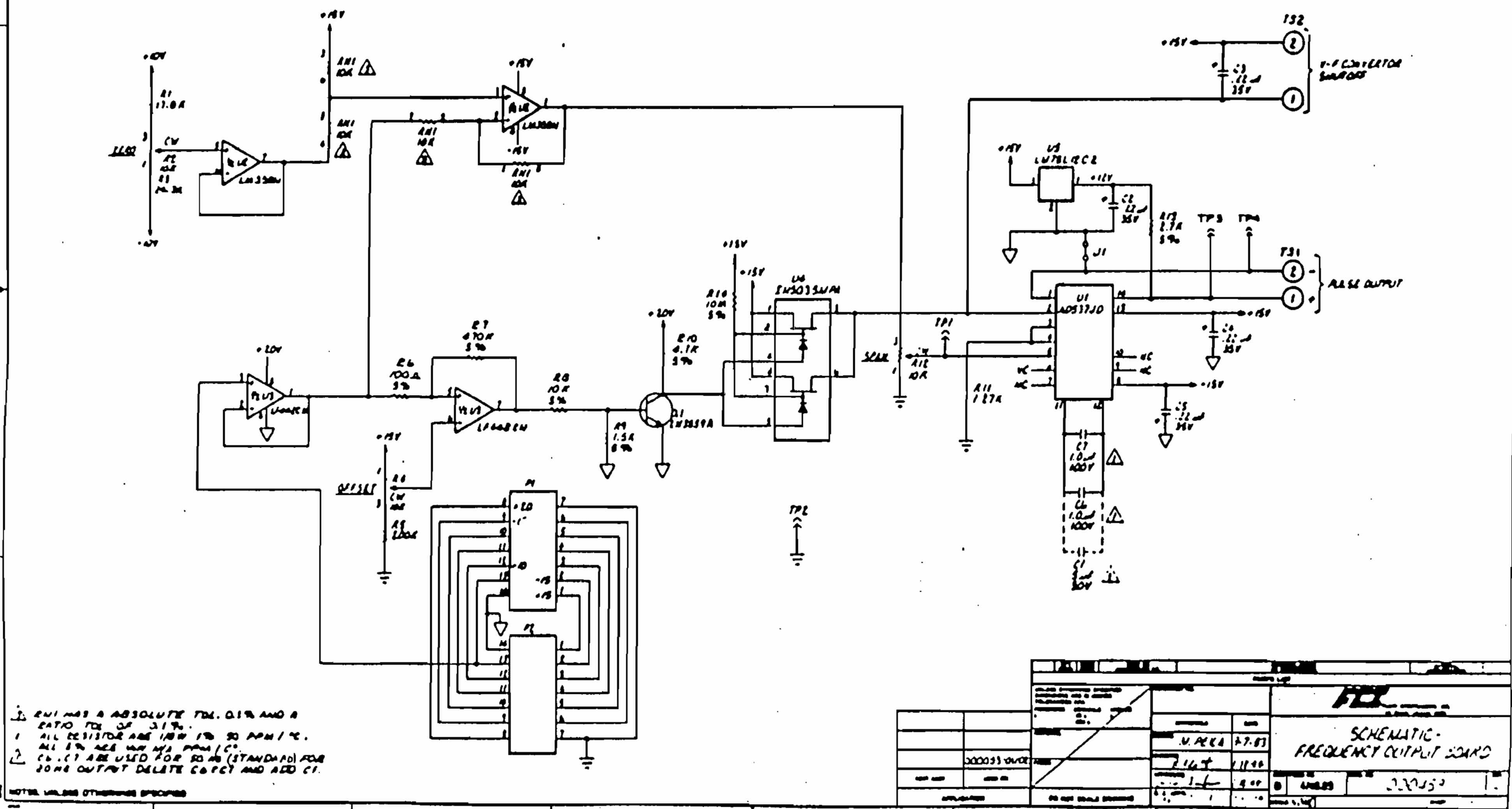
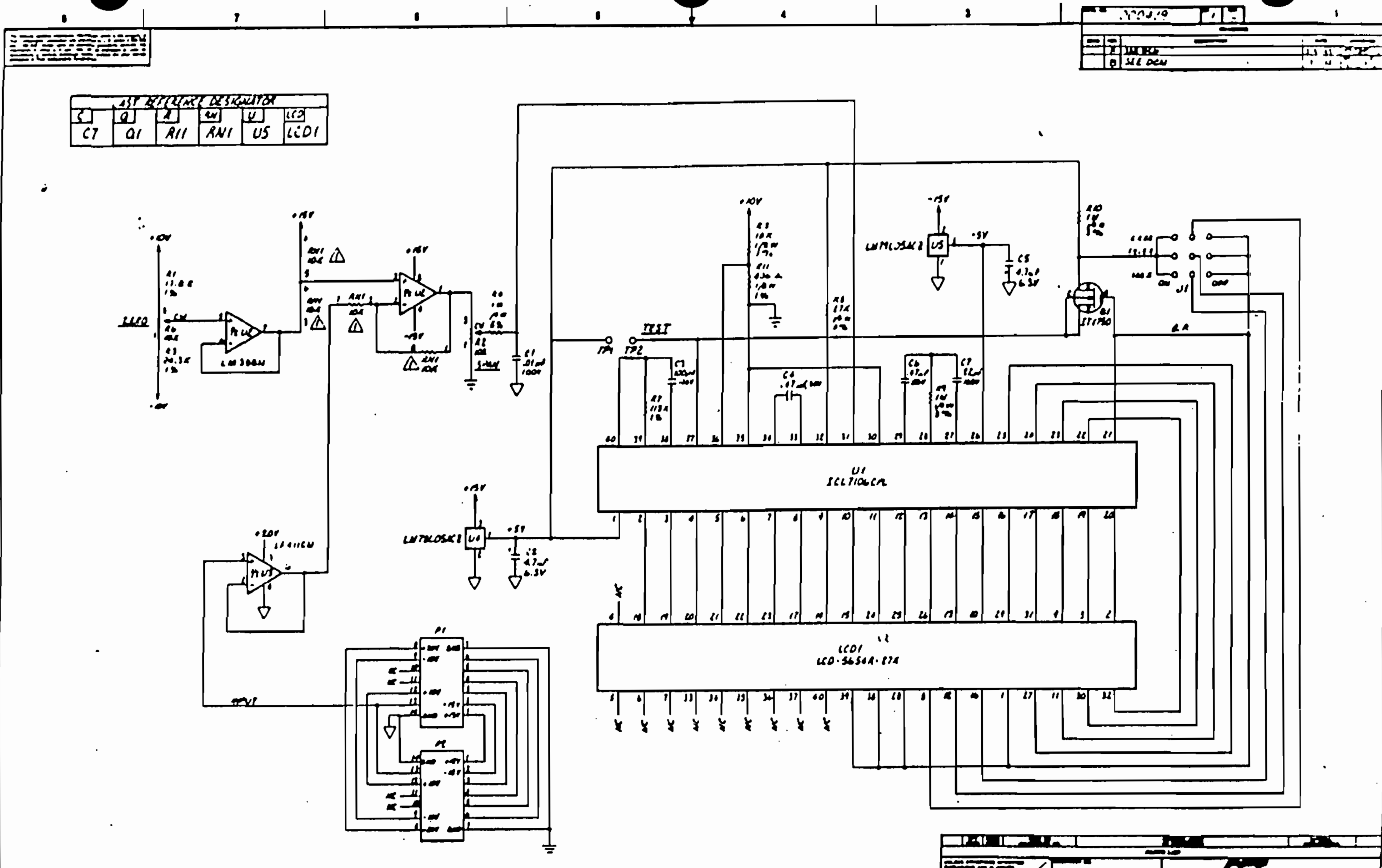




SCHEMATIC
LT 81 LOCAL READOUT

APPENDIX C - GLOSSARY

DELTA R (ΔR) -

The difference between two resistance values, generally in reference to the sensing RTDs.

DELTA T (ΔT) -

The difference between two temperature values, generally in reference to the temperature difference between the Active and Reference RTDs.

ELECTRONIC ASSEMBLY -

The circuit board stack (number of boards depends on your options) and the housing for this board stack. Refer to the "Physical Description" section for your configuration.

FLAT -

An area machined flat on the Sensor Probe Assembly indicating a surface which is to be aligned parallel to the flow (refer to the section on "Sensor Assembly Installation).

FLOW RATE -

A measure of the rate at which the medium is moving. May be expressed in terms of velocity (feet/sec), volume (actual cubic feet/min), or mass (1 lb/min. or standard cubic feet/min).

FMPT

Female National Pipe Thread is a standard tapered pipe thread with the threads on the inside of the pipe.

HIGH-LIMIT CURRENT -

The output current which corresponds to the higher flow rate parameter, either 20 or 50 mA.

HORIZONTAL FLOW -

A process medium flow that is parallel to the ground.

LOW-LIMIT CURRENT -

The output current which corresponds to the lower flow rate parameter, either 4 or 10 mA.

MNPT -

Male National Pipe Thread is a standard tapered pipe thread on the outside of the pipe.

RTD -

Resistance Temperaature Detectors are used as the sensing elements inside the thermowells of the Sensor Probe Assembly.

SENSOR PROBE ASSEMBLY -

That protion of the Flowmeter that contains the sensing elements.

TEST PLUG -

The unused 14 Pin IC socket on any of the circuit boards.

TURNDOWN RATIO -

Patio of the high flow rate to the low flow rate.

"U" DIMENSION -

A specific measurement on an LT81A Mass Flowmeter. The distance from the tip of the Sensor Probe Assembly to the outside edge of the process connection. Refer to the "Physical Description" section for the LT81A.

VERTICAL FLOW -

The process medium flows perpendicular to the ground.

APPENDIX D

ZERO BASED CALIBRATION EXPLANATION

NON-ZERO BASED CALIBRATION

Definition:

Minimum Flowmeter output is greater than zero. FCI's six segment linearizer board allows only non-zero based Calibration (Nuclear Applications).

Advantages:

Allows use of entire signal output range.

Recommendations:

Should be specified where minimum flow rates do not approach zero and turndown ratios are small.

ZERO BASED CALIBRATION

Definition:

Minimum flowmeter output equals zero. This is an optional calibration choice on the eight segment linearizer board. This board is standard with all commercial LT81A and LT87 Mass Flowmeters.

Advantages:

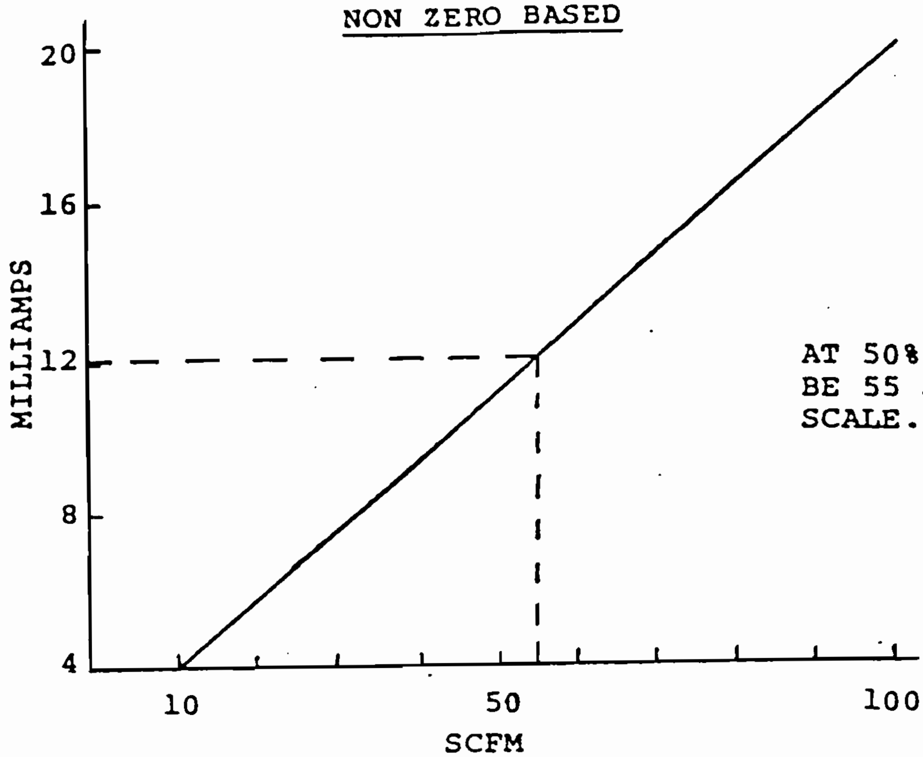
Signal output is easier to interpolate when milliamp ouput is interfaced with control room 0-100% gauges (i.e., 50% of signal corresponds to 50% of maximum flow rate). Refer to attached graph. Provides a more accurate value when customer is using 4-20 mA signal for flow totalization (i.e., during periods of zero flow output, flowmeter will send zero flow signal).

Disadvantages:

Zero based flowmeters have less resolution over the signal output scale. A zero based flowmeter with a 10:1 turndown ratio will have 10% less output range to resolve flow (5.6 mA to 20 mA instead of 4 mA to 20 mA for a non-zero based meter).

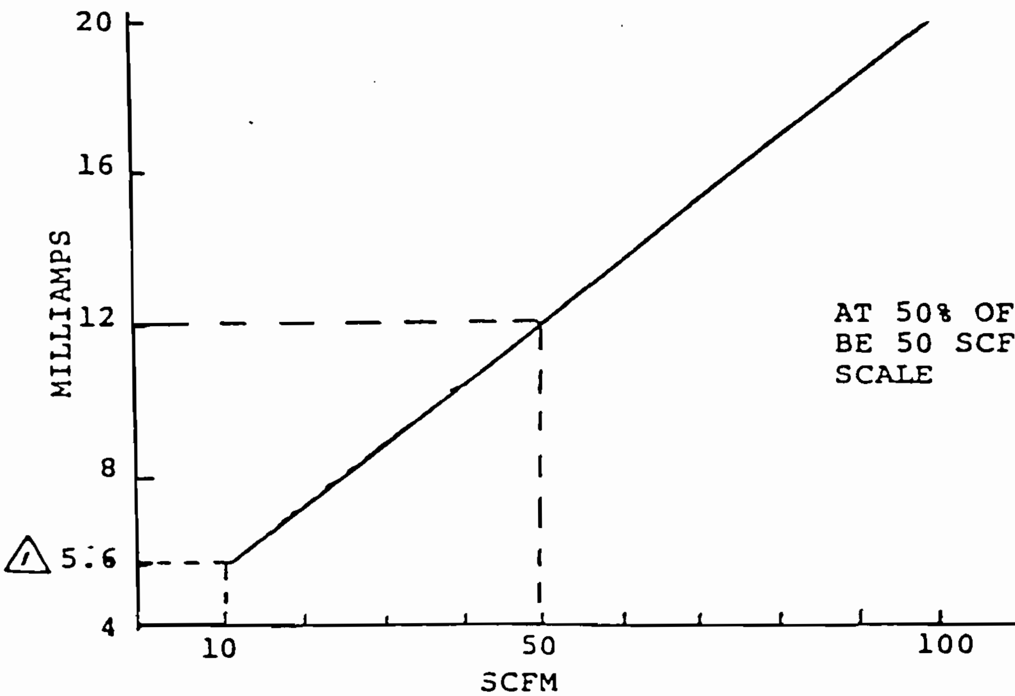
ZERO BASED EXPLANATION

NON ZERO BASED



AT 50% OF SIGNAL FLOW WILL BE 55 SCFM OR 55% OF FULL SCALE.

ZERO BASED



AT 50% OF SIGNAL FLOW WILL BE 50 SCFM OR 50% OF FULL SCALE

⚠ From 0 to 10 SCFM FCI instruments will read 4mA, at 10 SCFM instrument will read 5.6mA.

Many customers send mA output to analog meters where 4mA=zero flow and 20mA=100% flow. These customers usually need zero

NON ZERO BASED

FLUID COMPONENTS, INC.
1755 LA COSTA MEADOWS DR., SAN MARCOS, CA 92069, (800) 854-1993

CALIBRATION GRAPH PREPARED FOR AJAX

S.O. NO. 1234
P.O. NO. ....XYZ
TAG NO. ....
SERIAL NO. 5000
MEDIUM ....AIR
PRESSURE ....ATM.
TEMPERATURE (RANGE).....AMB.
LINE SIZE ....4"
ORIENTATION ....HORIZONTAL
MOUNTING ....SIDE
FLOW DIRECTION ....L - R

mA	SCFM	mA	SCFM	mA	SCFM
4.0	10.00	9.4	40.38	14.8	70.75
4.2	11.13	9.6	41.50	15.0	71.88
4.4	12.25	9.8	42.62	15.2	73.00
4.6	13.38	10.0	43.75	15.4	74.13
4.8	14.50	10.2	44.87	15.6	75.25
5.0	15.63	10.4	46.00	15.8	76.38
5.2	16.75	10.6	47.12	16.0	77.50
5.4	17.87	10.8	48.25	16.2	78.62
5.6	19.00	11.0	49.37	16.4	79.75
5.8	20.12	11.2	50.50	16.6	80.88
6.0	21.25	11.4	51.62	16.8	82.00
6.2	22.37	11.6	52.75	17.0	83.13
6.4	23.50	11.8	53.87	17.2	84.25
6.6	24.62	12.0	55.00	17.4	85.38
6.8	25.75	12.2	56.12	17.6	86.50
7.0	26.87	12.4	57.25	17.8	87.63
7.2	28.00	12.6	58.37	18.0	88.75
7.4	29.12	12.8	59.50	18.2	89.88
7.6	30.25	13.0	60.62	18.4	91.00
7.8	31.37	13.2	61.75	18.6	92.13
8.0	32.50	13.4	62.87	18.8	93.25
8.2	33.62	13.6	64.00	19.0	94.38
8.4	34.75	13.8	65.12	19.2	95.50
8.6	35.87	14.0	66.25	19.4	96.63
8.8	37.00	14.2	67.37	19.6	97.75
9.0	38.12	14.4	68.50	19.8	98.88
9.2	39.25	14.6	69.62	20.0	100.00

TEST TECH ___________

DATE _______________

ZERO BASED

FLUID COMPONENTS, INC.
1755 LA COSTA MEADOWS DR., SAN MARCOS, CA 92069, (800) 854-1993

CALIBRATION GRAPH PREPARED FOR AJAX

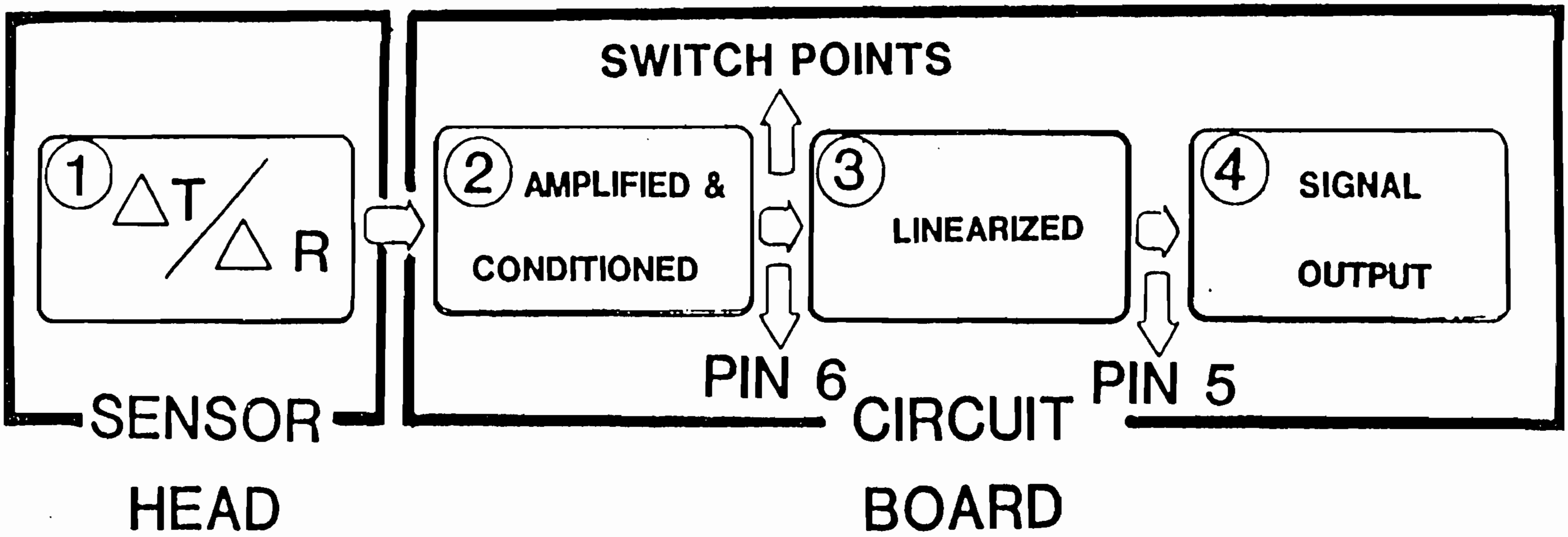
S.O. NO. 1234
P.O. NO. ....XYZ
TAG NO. ....
SERIAL NO. 5000
MEDIUM ....AIR
PRESSURE ....ATM.
TEMPERATURE (RANGE).....AMB.
LINE SIZE ....4"
ORIENTATION ....HORIZONTAL
MOUNTING ....SIDE
FLOW DIRECTION ....L - R

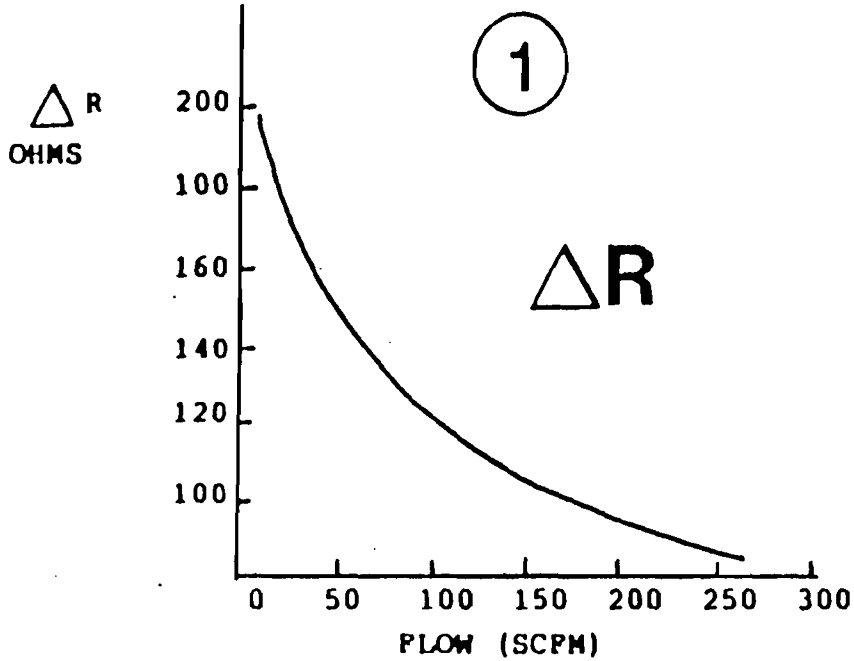
mA	SCFM	mA	SCFM	mA	SCFM
4.0	0.00	9.4	33.75	14.8	67.50
		9.6	35.00	15.0	68.75
		9.8	36.25	15.2	70.00
		10.0	37.50	15.4	71.25
		10.2	38.75	15.6	72.50
		10.4	40.00	15.8	73.75
		10.6	41.25	16.0	75.00
		10.8	42.50	16.2	76.25
5.6	10.00	11.0	43.75	16.4	77.50
5.8	11.25	11.2	45.00	16.6	78.75
6.0	12.50	11.4	46.25	16.8	80.00
6.2	13.75	11.6	47.50	17.0	81.25
6.4	15.00	11.8	48.75	17.2	82.50
6.6	16.25	12.0	50.00	17.4	83.75
6.8	17.50	12.2	51.25	17.6	85.00
7.0	18.75	12.4	52.50	17.8	86.25
7.2	20.00	12.6	53.75	18.0	87.50
7.4	21.25	12.8	55.00	18.2	88.75
7.6	22.50	13.0	56.25	18.4	90.00
7.8	23.75	13.2	57.50	18.6	91.25
8.0	25.00	13.4	58.75	18.8	92.50
8.2	26.25	13.6	60.00	19.0	93.75
8.4	27.50	13.8	61.25	19.2	95.00
8.6	28.75	14.0	62.50	19.4	96.25
8.8	30.00	14.2	63.75	19.6	97.50
9.0	31.25	14.4	65.00	19.8	98.75
9.2	32.50	14.6	66.25	20.0	100.00

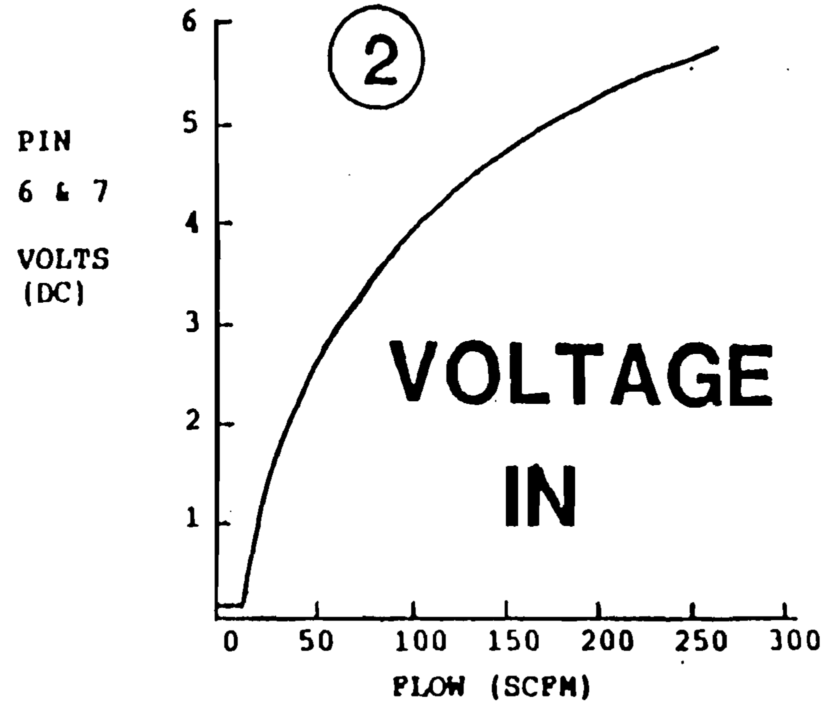
TEST TECH ___________

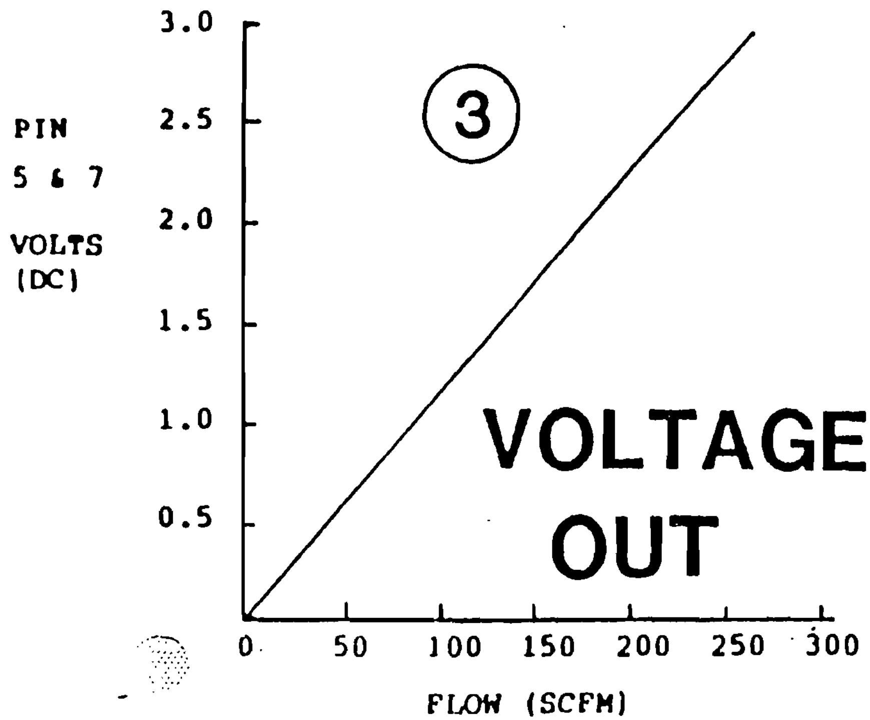
DATE _______________

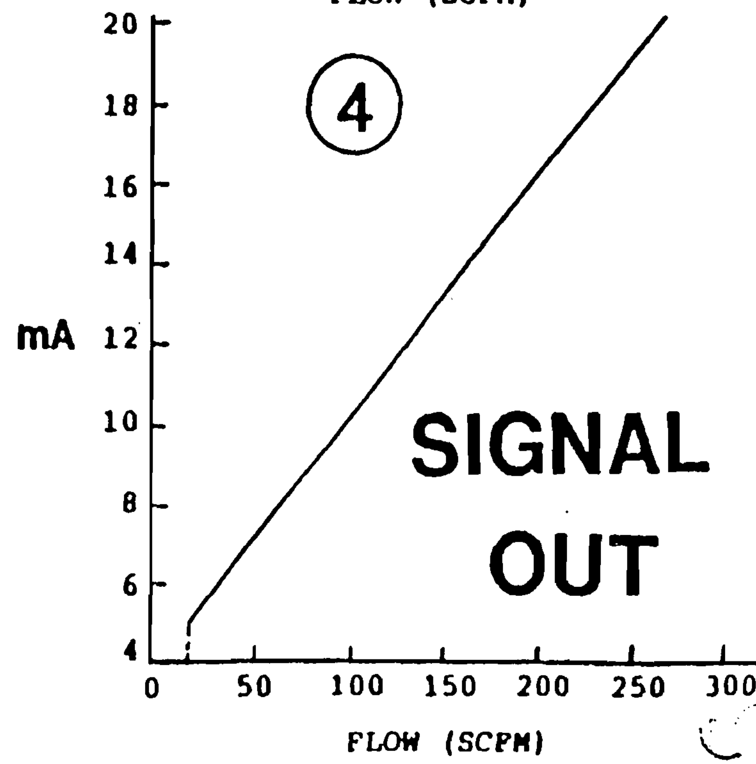
THEORY OF OPERATION

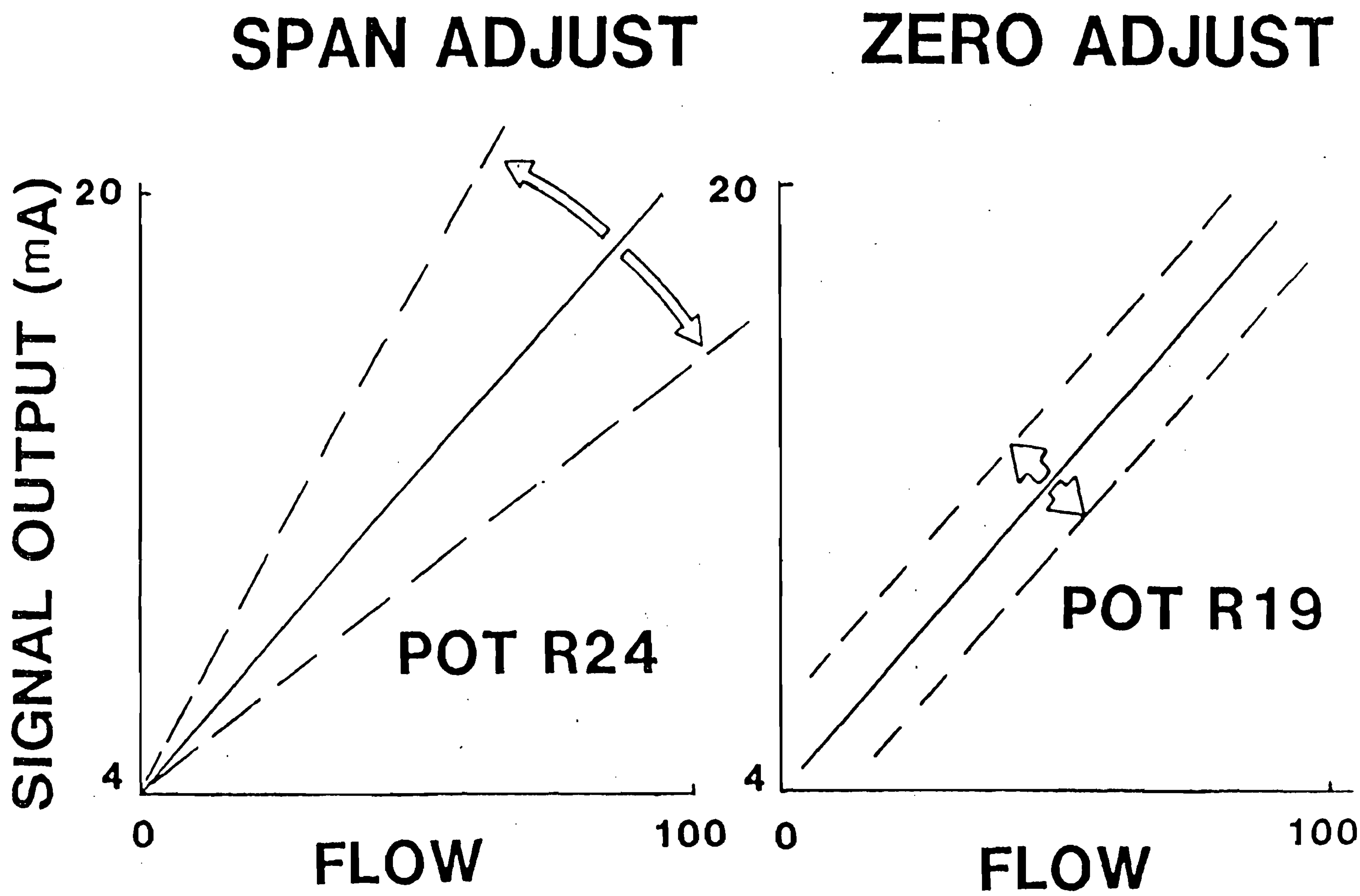



1
ΔR
ΔR OHMS
200
100
160
140
120
100
0 50 100 150 200 250 300
FLOW (SCFM)


2
VOLTAGE IN
PIN 6 & 7
VOLTS (DC)
6
5
4
3
2
1
0 50 100 150 200 250 300
FLOW (SCFM)


3
VOLTAGE OUT
PIN 5 & 7
VOLTS (DC)
3.0
2.5
2.0
1.5
1.0
0.5
0 50 100 150 200 250 300
FLOW (SCFM)


4
SIGNAL OUT
mA
20
18
16
14
12
10
8
6
4
0 50 100 150 200 250 300
FLOW (SCFM)


SPAN ADJUST
ZERO ADJUST
SIGNAL OUTPUT (mA)
20
4
0
100
FLOW
POT R24
20
4
0
100
FLOW
POT R19

FLORIDA FIRST PROCESSING, L.P.

APPENDIX D-4-11

OPACITY MONITORING SYSTEM

(2)

Dynatron INC.
ENERGY CONSERVATION SYSTEMS
Barnes Industrial Park, Wallingford, Connecticut 06492 U.S.A.
P.O. Box 745 - Cable: Dynatron WFOD - Telex: 956043

CONTINENTAL USA ONLY CALL TOLL FREE 1-800-243-3124	CONNECTICUT AND WORLDWIDE 1-203-265-7121

CONTINUOUS MEASUREMENT OF OPACITY AND PARTICULATE MASS EMISSIONS WITH DYNATRON MODEL 1100M OPACITY MONITORING SYSTEM

Prepared by: James F. Cognetta
V.P. International Sales

TABLE OF CONTENTS

SECTION

SECTION 8 Control Monitor PC Boards

SECTION 9 Appendix

SECTION 1

Theory of Operation

Two standard methods for the continuous measurement of particulate emissions are:

Determination of the Ringelmann number or the equivalent opacity of visible emissions;

Manual sampling using particulate sampling trains.

The problems of judging visual emissions by human observers are well known. The original Ringelmann scale, comparing the shade of gray of smoke with that of a chart, is useful only for black smoke emissions. Today, smoke readers are trained to judge the equivalent opacity of emissions of any color. However, the results are dependent on the position of the sun relative to the observer; errors are made on overcast days, and no observations can be made at night. The reading errors were acceptable for Ringelmann numbers 3 and 2 but are unacceptably large for today's requirement of Ringelmann number 1 (20% opacity) or 1/2 (10% opacity).

As currently practiced, smoke shade observations bear little relationship to particulate loading in the gas or to particulate mass emissions. The most obvious inadequacy is the dependence of the observed smoke shade on the stack exit diameter. The same smoke is darker for a large diameter than for a smaller one. In addition, smoke density is a function of the density of the emitted material, the particulate size distribution, and the optical properties of the particles. In fact, visible emission regulations are primarily intended to control the appearance of the stack plume, not the quantity of emissions. However, indirectly and in a very inadequate way, they also cntrol particulate mass emissions. For example, a modern plant may comply with applicable particulate emission standards, yet it may be forced to reduce emissions even further to meet opacity requirements.

The second method is the reference method for measuring particulate emissions (EPA Method 5 Sampling), or VDI 2066 can be followed in the gravimetric determination of the dust content. These are laborious manual procedures which in large stacks may require 2-4 man weeks of time and a cost from $5,000.00 to $15,000.00.

Sampling annually or biannually does not provide information about performance of control equipment during intervals between measurements.

Clearly, a better method for measuring and continuously monitoring particulates is needed. The Dynatron microprocessor-based monitoring system conforms with the latest United States Environmental Protection Agency (EPA) opacity monitoring regulations for both continuous and intermittent emission sources. There are over 1,000 of these instruments now in operation in Europe, Asia, and North America.

Combination Sensor Blower Weather Cover

with Integral Heat Shield Mounting Plate

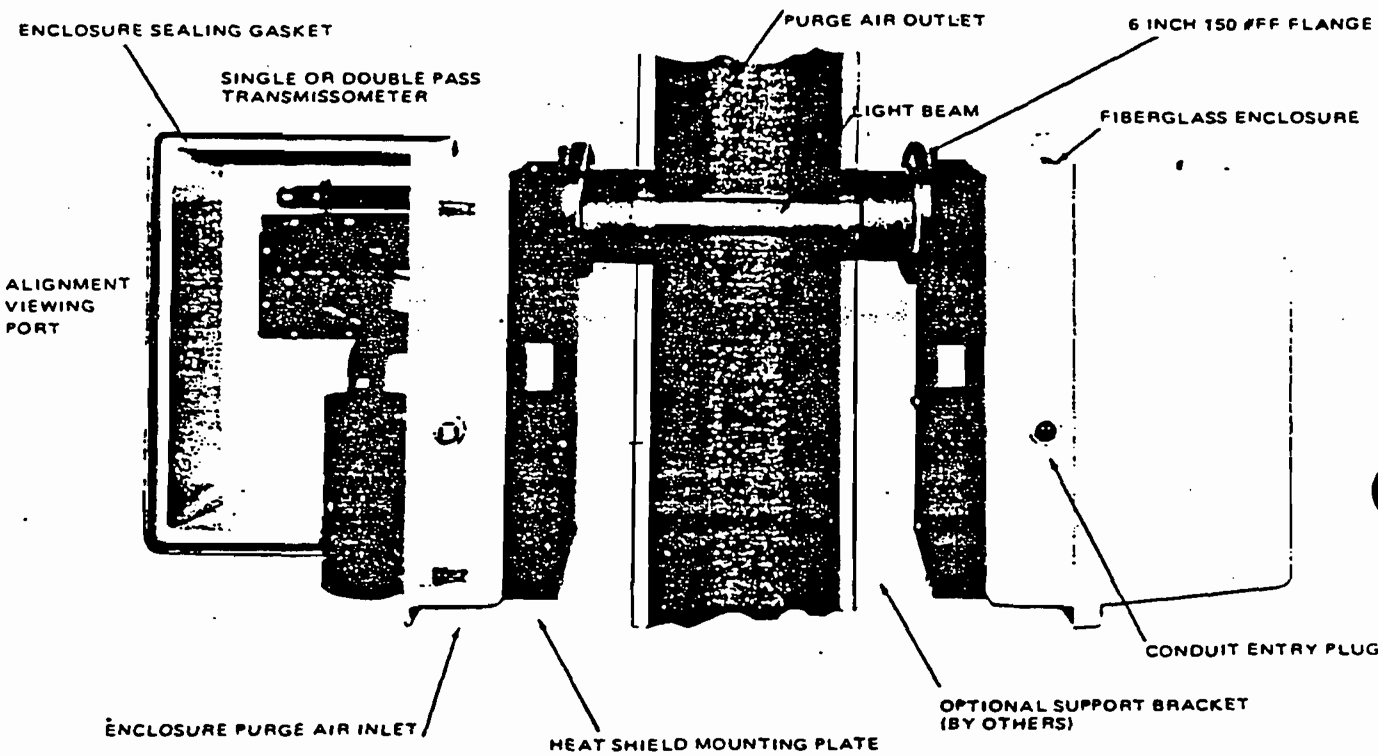


Figure 1

Transmissometer

Housing - Fig. 1

The light source is usually mounted in a very poor environment. The optics and any electronics must either survive this environment or be thoroughly protected from it. Dynatron has taken a number of steps to protect the transmissometer.

The transceiver is packaged in a metal case with full gaskets at the parting surface. A glass window seals the optics from exposure to the stack gases. The transceiver is mounted in a full and completely sealed fiberglass enclosure. The retroreflector is housed in an identical enclosure. Errant currents of air around the stack cannot enter the enclosure from the bottom. The enclosure is fairly compact requiring only 31-3/4 inches (793 mm) maximum to open. When closed, the depth is only 23 inches (589 mm), allowing movement around it even on 3-foot (1-meter) walkways or platforms. An air purge system with triple filtration constantly circulates air past the viewing window. This air flow is directed through an annular passage toward the stack. This passage is on the stackside of the viewing/sealing window and removable glass slide. The air flow in the reduced cross sectional area results in a reduced pressure and increased velocity. This venturi effect tends to continually draw the air around the viewing window into the purge airstream, thereby insuring the window stays clean for long periods.

Light Modulation

Light modulation is used in all current systems to avoid errors caused by ambient light reflecting off particles in the stack gases. Without the modulation, the detector would measure all reflected light. Dynatron uses solid-state AC light modulation rather than electromechanical choppers. There are no moving parts or electronics in the transmissometer. AC voltage on the bulb filaments extends bulb life. In total, these steps mean fewer non-scheduled trips up the stack.

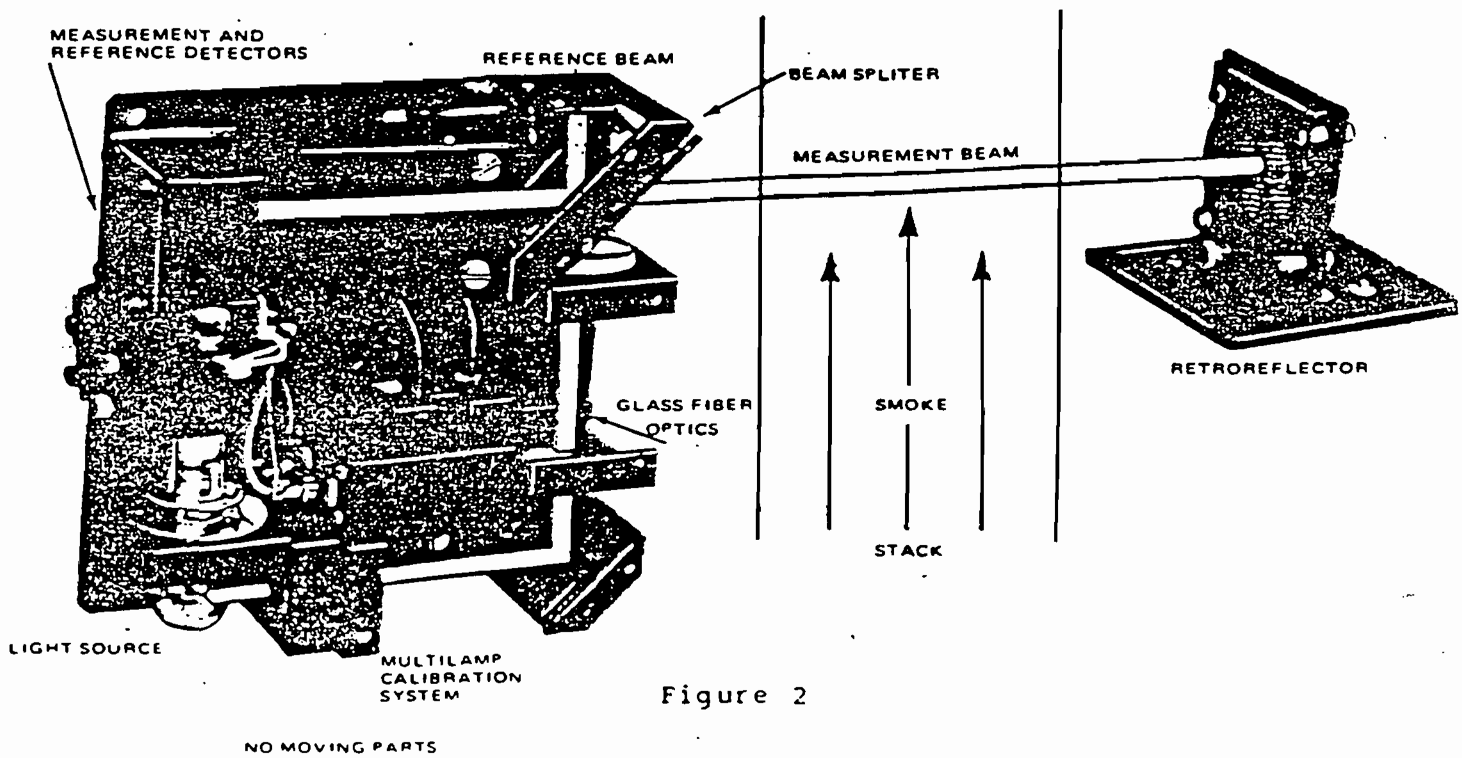


Figure 2

Measurement

Fig. 2 - The next step in the function of the double pass system is the comparison of the measured opacity with a created zero opacity. The techniques employed vary. Nearly all systems employ a motor to drive a mechanical chopper and also to rotate the zero reflectors and zero/span filters. By alternately detecting measurement and zero (reference) signals after passing through a beam splitter, an opacity value is obtained.

Dynatron has taken a different path. The light beam passes through a beam splitter. Half the light is directed through fiber optics to a reference detector and resulting voltage Vr. The other half is directed across the stack to the retroreflector and then back through some optics to a separate detector for a measurement signal Vm. The ratio (Vm/Vr) provides electrical signals to calculate opacity, optical density, and transmittance. Because the same light source is used for both detectors, and Vm/Vr ratio is used throughout, the Dynatron system is insensitive to variations in the light intensity. The Dynatron system is all solid-state and does not require any mechanical devices. Since all measurements are made on a ratio basis, all resulting computations are automatically compensated for variations in light source intensity and thus are independent of the absolute intensity of the light source.

Automatic Calibration and Correction

The Model 1100M microprocessor automatically eliminates effects of zero and span measurement errors due to all causes including: component aging, line voltage fluctuations ± 10% of nominal and ambient temperature variations -30°F to +150°F (-30°C to +63°C).

The calibration cycle is used to re-establish the zero output so that the resultant zero measurement error is less than 0.1% opacity. Correction occurs during each zero span check cycle whether activated manually or automatically at preset time intervals (adjustable from 1 to 99 hours). Maximum correction is limited to a dynamic range of -10% to +5%.

Tolerance for Misalignment

Another common source of error in smoke measuring installations is a variation in alignment as a result of buckling and temperature movements of the stack or duct walls to which the instrument is attached. As a result, some instruments require the installation of a slotted pipe across the duct or stack to maintain rigid alignment. Among the disadvantages of this arrangement are the possibility of measuring a non-representative sample of the smoke or dust, a reduced instrument sensitivity as a result of measuring only the smoke passing through the slotted section of the pipe, and the possibility of light vignetting, i.e., scattered light is reflected off the walls and reaches the detector. In large installations and at high operating temperatures, such a pipe can sag, causing a large measurement error, and the pipe usually is not recommended for stack widths greater than 20 feet. The 1100M instrument system does not utilize a pipe across the smoke channel, and it can be used over distances as great as 70 feet (21.3 meters).

The instrument system tolerates commonly encountered alignment changes up to ± 0.25° without loss in accuracy. The light beam is focused on the retroreflector for each specific distance and has a uniform intensity throughout its cross section at the focal distance. For each specific distance, a reflector aperture size is adjusted that will maintain a large ratio of beam cross sectional area to reflector area. Since the beam is uniform, the retroreflector always returns a constant amount of light regardless of what portion of the beam impinges upon the retroreflector. Furthermore, the corner cube retroreflector always returns light directly to the source regardless of the angle of incidence. Within its accuracy specifications, this instrument system tolerates alignment changes of ± 0.25%, which is equivalent to measuring beam movements of .5 to 1.5 inches at distances of 10 to 30 feet. This is sufficient to account for all alignment variations encountered in actual practice.

"Bulls-Eye" Alignment Telescope

This enables the operator to visually check system alignment to determine not only when the light source beam is covering the retroreflector, but also when the retroreflector is in the center of the beam so as to minimize the effect of thermal stack shift on system alignment. It consists of an alignment telescope and a lit target on the retroreflector side of the stack.

Accuracy and Sensitivity

As a result of the design features described, the instrument system achieves the following:

Transmissometer Sensor System

Path Length	8 in. to 70 ft. (0.2 to 21.3 m)
Optical System	Double Pass
Light Source Aging Compensation	Automatic
Light Source Life (3 yr. warranty)	30,000 hrs.

Enclosure	NEMA 4 Watertight
Alignment Verification	Telescope and Illuminated Target
Pull-Out Slide Assembly	Stainless Steel and Glass Sealed w/Silicone Rubber Gasket
Ambient Light Immunity	Solid-State Electronic Light Modulation and Digital Cross Correlation Signal Conditions Eliminate Possible Interference Due to Ambient Light
Wiring (Standard 18-Gauge, Twisted, Shielded Pairs (One Cable)	9 Pair, Includes Spares and Communication Link Up to 1 Mile (1600 m)

<u>The Model 1100M Meets All Applicable EPA Design and Performance Requirements</u>

Peak Spectral Response	515-585 nm
Mean Spectral Response	515-585 nm
Relative Spectral Response	$<$10%
Angle of View	$< \pm 5^{\circ}$
Angle of Projection	$< \pm 5^{\circ}$
Calibration Error	$< \pm$ 2% of full scale
Response Time	1 second, internal
Zero Drift	$<$1% (24 hrs.)
Calibration Drift	$<$1% (24 hrs.)
Zero/Span Check	24 hrs.
Operational Test Period	168 hrs.
Operational Period	3 to 6 months

<u>Air Purge Weather Cover System</u>

Enclosure	Fiberglass
Heat Shield	Standard

Air Purge Blowers (Others Available on Special Order)	2 Per System 10 SCFM 0.35 m^3/min at 60Hz 33 in H_2O (838mm H_2O) 50Hz 25 in H_2O (635mm H_2O)
Air Filtration	Three Stage: Screen Cyclone Cartridge
Temperature Limits	-22° to 150°F
Ambient	(-30° to 63°C)
Stack Gas - Max.	750°F
(Others Available on Special Order)	(400°C)
Power Requirements Air Purge Blower	115/230 Volts 1 Phase ± 10%
	50Hz 2.8 FLA 10.5 LRA 60Hz 3.7 FLA 10.0 LRA
Weight - lbs. (kg.)	76 (34) Each Side Qty. 2 Required

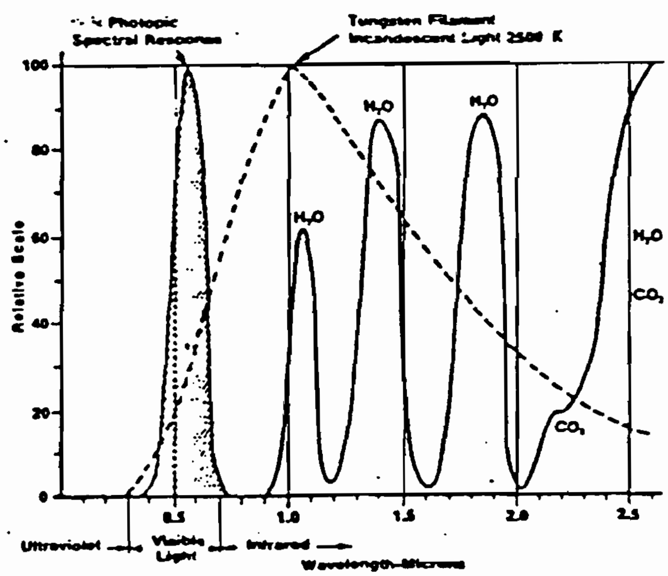


Figure 4

Photopic Light

An additional requirement for absolute accuracy of the measurement is a specified spectral range, since light attenuation by a polydisperse aerosol with mean particle size of less than 1 micron is a function of the wavelength of the light. The specified spectral distribution is photopic, the same as that of the light-adapted human eye, because one objective is the measurement of the opacity of visible emissions as observed by the human eye.

The instrument utilizes a photocell/filter combination to achieve "photopic" spectral sensitivity. Figure 4 shows the spectral sensitivity of the instrument compared to the output of an incandescent light source. The maximum light intensity is at 0.55 micron wavelength compared to about 1.0 micron for the incandescent source. Instruments sensitive to the entire output of the light source are subject to two serious errors. First, water absorption bands in the near infrared portion of the spectrum cause large measurement errors for stack gases containing high humidity. Second, the instrument response to submicron particulate matter is significantly lower than the response of the human eye resulting in low readings when the stack emissions contain substantial portions of submicron particulate matter.

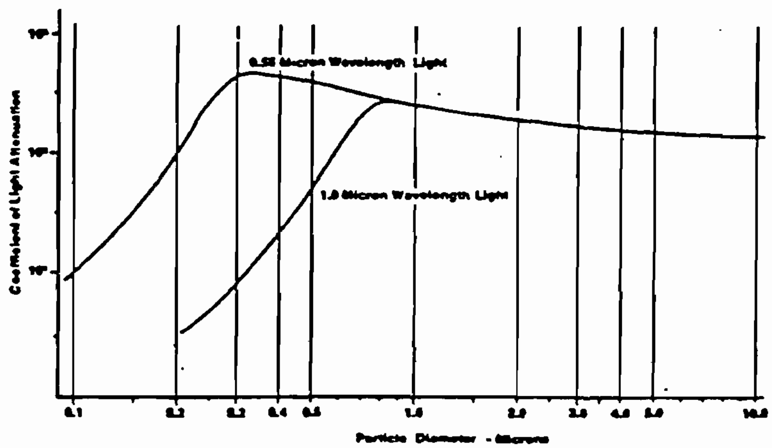


Figure 5

Figure 5 shows the light attenuation of a polydisperse aerosol for two different spectral maxima as a function of the mean particle size.[7] The attenuation of the 1.0 micron light falls off significantly at about 0.8 to 0.6 micron particle size while the 0.55 micron light is attenuated by particulate matter down to 0.3 to 0.2 micron size.

In the absence of photopic light, and especially when the major instrument response is within the infrared region, as in instruments utilizing a bolometer detector cell, large errors result when the emissions contain large portions of submicron particulate matter. This generally occurs in modern plants with strictly controlled emissions, since the control equipment primarily removes the larger particle sizes while submicron particles pass through.

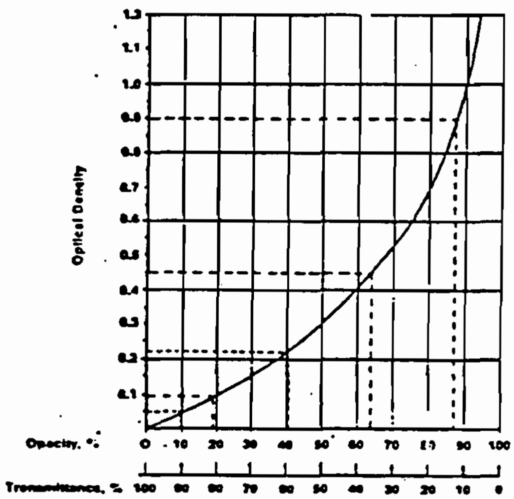


Figure 6

Instrument Output

Figure 6 shows the relationship between the optical density output of the instrument and the more familiar scales of opacity or transmittance. Optical density (D) is defined as the logarithm (base 10) of one over transmittance (T):

$$D = \log 1/T = -\log T \quad (1)$$

Since opacity (O) is defined by O = 1 - T, the relationship with optical density can be expressed as:

$$D = -\log T = -\log (1 - O), \text{ or}$$

$$T = 1 - O = 10^{-D} \quad (2)$$

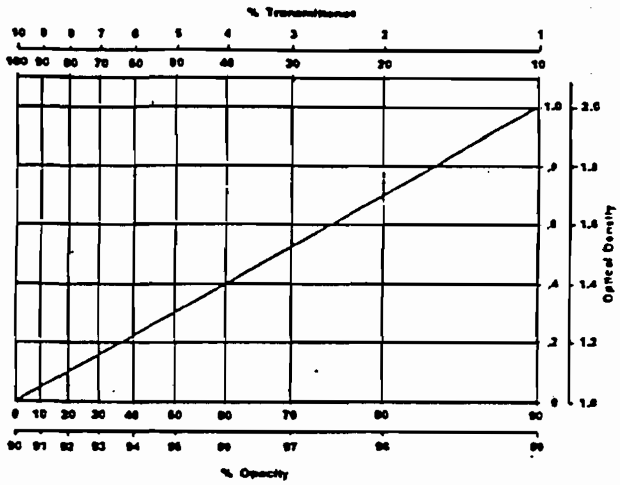


Figure 7

If T or (1 - O) is plotted on a logarithmic scale, a linear correlation is obtained as shown in Figure 7. The above relationship is known as Bouguer's Law, equivalent to the well known Lambert-Beer's Law for the measurement of absorbance by colored solutions. It can be shown that the optical density for the case of light attenuation by a smoke or dust aerosol, like the absorbance for the case of light absorption in solutions, is proportional to the pathlength (d) and the concentration (c) of the light attenuating material.

$$D = K \cdot c \cdot d \qquad (3)$$

This relationship is used to correct the measured optical density values (D_1) for the measuring distance (d_1) at the instrument installation site to the values (D_2) applicable for the stack-exit diameter (d_2). Since a folded-beam instrument measures through twice the smoke width at the installation site, the distance d_1 must be taken twice as follows:

$$D_2 - D_1 \cdot d_2/2d_1 \qquad (4)$$

The corrected optical density values can then be converted to opacity units by means of the graphs in Figures 6 or 7, or equation (1), or by using readily available tables (Handbook of Chemistry and Physics), or nomographs. The Dynatron 1100M micro control unit which is intended for installation on the instrument panel in the plant control room is supplied. It allows the selection of readouts in terms of either optical density or opacity at the measuring site, optical density or opacity at the stack exit, and either or both of these outputs can be recorded on a strip chart recorder. The available measurement ranges indicated in Figure 6 are single pass equivalents of the instrument's double pass measurements.

Correlation With Dust Loading

According to Bouguer's Law, the optical density instrument readout is directly proportional to the dust concentration in the gas. The constant of proportionality differs with the density of the particulate matter, its size distribution, and its optical properties. The constant can be calculated if all data are known.[5,8,9] In practice, it is easier to experimentally determine the proportionality constant for each installation.[2,10-12]

Empirical calibration of the transmissometer, in terms of particulate concentration, requires at least one data point obtained by stack sampling using an approved sampling train and method. The average of the transmissometer readings over the period of the stack sampling test equals the measured dust concentration in mg/m^3 or gr/ft^3 at actual conditions. A straight calibration line is drawn from the origin through the experimental point.

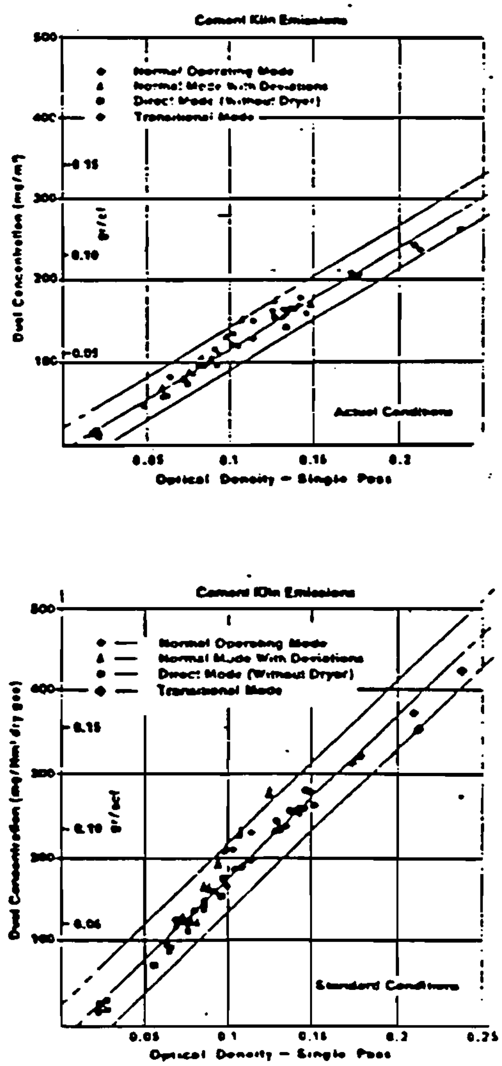


Figure 8

Calibration in terms of dust loading is valid only as long as the particle size distribution and other particulate properties do not change significantly. This condition is generally ful-filled in emissions from sources with control equipment of high efficiency. To establish the accuracy of the caibration over a range of emission rates and process conditions, a large number of calibration points (at least 12 to 15) must be obtained and the regression line and its confidence limits determined. Figure 8a illustrates a calibration curve obtained on the stack of a cement kiln equipped with an electrostatic precipitator. The 95% tolerance intervals at the 95% confidence level are indicated in the figure. Figure 8b shows the same calibration curve after correction to standard conditions (temperature, pressure) and dry gas. The corrected calibration curve can be used when gas temperature, pressure, and humidity are constant. Figure 9 shows a similar calibration curve obtained on a lignite-fired boiler, and Figure 10 shows a similar calibration curve for a bituminous coal-fired power station.

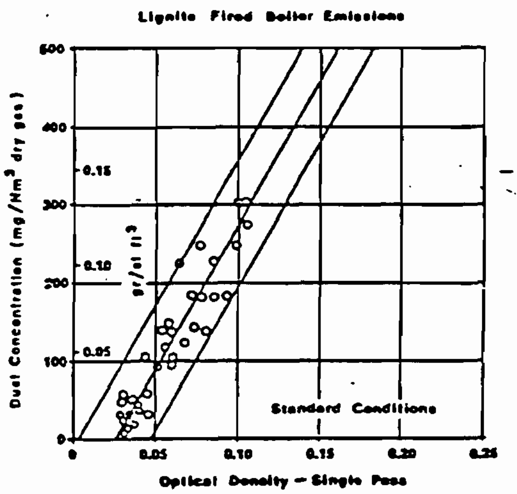


Figure 9. Relationship between optical density and particulate mass concentration for a lignite fired boiler (standard conditions).

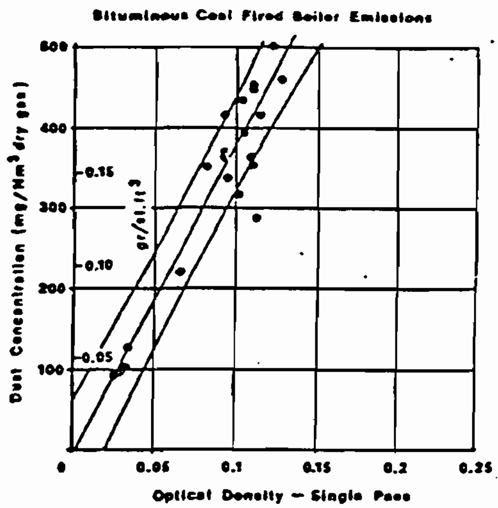


Figure 10. Relationship between optical density and particulate mass concentration for a bituminous coal fired boiler (standard conditions).

Figures 9 and 10

The system is being used in numerous installations throughout the world for the continuous monitoring of both opacity and par-ticulate concentration, based on the correlations established between the optical reading and the dust loading. In this appli-cation, the instrument calibration, in terms of particulate con-centration, is checked by manual testing once a year. In evaluating the monitoring record, credit for the possible measurement error is given.

Table I summarizes the levels of error observed in a number of correlation lines for typical emission sources. Four different definitions of error have been applied. The error definitions are as follows:

A. Standard deviation is the root of the mean.

B. Type 1 error is the 95% confidence level that the true mean of all observed optical data for a given particulate concentration will lie within the limit.

C. Type 2 error is the 95% confidence level that the next one observation will fall within the limit.

D Type 3 error is the 95% confidence level that 95% of all possible observations (95% tolerance) will fall within the limit.

In Europe, Type 3 error calculation is typically applied, while in the U.S., the Type 2 calculation is most common. The smallest error level is obtained by the Type 1 method. As a percentage of the measured mean particulate concentration, the Type 1 error level ranges from 5 to 21.1%.

If the transmissometer data were correlated with 1 hr. stack sampling data, an individual data point in the continuous transmissometer recording would be defined as a 1 hr. average reading.

The continuously recording 1100M easily allows the output to be averaged from 1-99 minutes. If any of the averages exceeds a predetermined value, controls are activated automatically. The longer term averages improve the accuracy and reliability of the emission data recorded.

The correlation data available from different emission sources allow a comparison of stack opacities resulting from different emission sources at equal particulate concentrations and stack diameters. Some calculated opacities for a concentration of 150 mg NM^3 (0.071 gr/scf) and a stack exit diameter of 3m (10.12 ft.) are summarized in Table II.

Scope of Applications

Use of the instrument for a continuous monitoring of particulate mass concentrations has been proven in the following categories of emission sources:

coal and oil-fired power stations
residual fuel oil-fired industrial boilers
Kraft recovery and hogged fuel fired boilers
refuse incinerators and teepee burners
wet and dry process cement kilns
catalytic cracker regenerators
glass furnaces
turbine engine test cells
coke ovens
electric furnaces

when installed following electrostatic precipitators, the instrument precisely records the fluctuations resulting from precipitator rapping. It indicates malfunctions and allows proper sequencing of rapping and adjustment of the precipitator for maximum performance (fine tuning).[15]

The instrument system also monitors sodium losses on Kraft recovery boilers[13] and catalyst losses from catalytic cracking regenerators. The instrument's capability is without equal for accurately measuring low opacity values as required for cement and glass plant emissions and turbine engine tests. In monitoring the combustion process of oil-fired facilities or waste incinerators, the instrument can be reliably used for the automatic control of overfire air, fuel additive, or other adjustments.

Following a fabric filter system, the instrument clearly shows a surge of emission whenever a compartment comes back on line after cleaning. A bag leak is signalled by a rising baseline of emissions but a sharp drop to normal levels whenever the compartment with the leaking bag is closed off for cleaning.

In closing, it is evident that there are many applications in which a state-of-the-art opacity system may be used. For further inquiries or application questions, contact us here at Dynatron.

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Table I. Error levels for correlations between optical density measurements and particulate mass concentration.

	No. of observ.	Correl. coeff.	Mean part. conc. (mg/Nm³)	Error Level (mg/Nm³) At Mean of Part. Conc.: Std. dev.	95% Confid. True mean	95% Confid. Next single value	95% Confid. 95% of all poss. values
Cement	39	0.985	179.9	±13.9	±9.0 (5.0%)	±57.2 (31.8%)	±68.6 (38.1%)
Bituminous coal	20	0.760	322.3	±85.5	±40.2 (12.4%)	±184.0 (57.1%)	±475.4 (147.5%)
Lignite	36	0.915	111.2	±31.4	±10.6 (9.5%)	±64.6 (58.1%)	±78.1 (70.2%)
Municipal incinerator	15	0.909	90.3	±29.5	±16.4 (18.2%)	±65.7 (72.7%)	±88.5 (98.0%)
Kraft recovery[13]	12	0.957	76.4	±12.6	±16.1 (21.1%)	±57.9 (76.0%)	±81.6 (106.8%)
Hogged fuel[14]	13	0.750	206.0	±61.8	±39.0 (18.9%)	±145.6 (70.7%)	±201.2 (97.6%)
Bituminous Coal[14]	11	0.974	252.3	±56.4	±38.4 (15.2%)	±133.2 (52.7%)	±379.5 (150.4%)

Table II. Comparison of stack opacities for different emission sources under equalized conditions.

Emission source	Mean part. conc. (mg/Nm³)	Single pass O.D. at mean of part. conc.	Diam. at measuring site (m)	Calcul. for 150 mg/Nm³ and 3 meter stack diam.: O.D.	% Opacity
Cement	179.9	0.1029	1.95	0.1320	26.2
Bituminous coal	322.3	0.0944			
Lignite	111.2	0.0580	3.25	0.0722	15.3
Municipal incinerator	90.3	0.0235	4.00	0.0293	6.6
Kraft recovery	76.4	0.0746	3.66	0.1200	24.2
Hogged fuel	206.0	0.1290	1.52	0.1854	34.8
Bituminous coal	252.3	0.1432	4.88	0.0523	11.3

SECTION 2

Installation

SECTION 2

Installation

SPECIFICATIONS

Specifications subject to change without notice. Dynatron reserves the right to make product improvements at any time.

Digital Display	5/8 in. (15.9 mm) 4-digit L.E.D.
Opacity	
Range	0-100%
Resolution	1%
Optical Density	
Range	0-1.02
Resolution	0.01
Indicator Lights/Contact Closures	
Early Warning 0-100%	5 amp 115v - 1 amp 220v
Alarm 0-100%	5 amp 115v - 1 amp 220v
Auto Calibration	5 amp 115v - 1 amp 220v
Fault/Diagnostics	5 amp 115v - 1 amp 220v
Analog Outputs	2 independent channels
Standard Output Format	4-20ma or 0-20ma grounded references
Maximum Compliance	24 volts
Load Impedance (Maximum)	1200 ohms
Signal Smoothing	1-99 sec.
Signal Averaging	1-99 min.
Linear Scale Expansion (Analog Output)	0-20% full scale (operator selectable)
Signal Smoothing	1-99 sec.
Signal Averaging	1-99 min.
Auto Calibration Repeat	1-99 hrs.

Exit Correlation (Lx/Lt)	.2 - 5
Fault Codes	6
Diagnostic Modes	12
Enclosure	panel mounting DIN Standard 43831 dust-tight
Ambient Temperature Range	40^o-125^oF(4.4^o-51.6^oC)
Power Requirements	115v, 50/60Hz, 1Ph, $\pm$10% 1 amp 230v, 50Hz, 1Ph, $\pm$10% 0.5 amp (original order only)

<u>TRANSMISSOMETER SENSOR SYSTEM</u>

Path Length	8 in.- 70 ft.(0.2-21.3 m)
Optical System	double pass
Light Source Aging Compensation	automatic
Light Source Life	30,000 hrs.
Enclosure	NEMA 4 (IP-65) watertight
Alignment Verification	telescope & illuminated target
Wiring (Standard) 18 Gauge, Twisted Shielded Pairs	9 pairs includes spares up to 1 mile (1600 m)

<u>DESIGN AND PERFORMANCE</u>

Peak Spectral Response	515-585 nm
Mean Spectral Response	515-585 nm
Relative Spectral Response	less than 10%
Angle of View	less than 5^o

Angle of Projection	less than 5°
Calibration Error	less than 2% of full scale
Response Time	1 sec. internal
Zero Drift	less than 1% (24 hrs.)
Calibration Drift	less than 1% (24 hrs.)

AIR PURGE WEATHER COVER SYSTEM

Enclosure	fiberglass
Heat Shield	standard
Air Purge Blower Power Requirements	115/230v, 1Ph, ±10% 50Hz 2.8 FLA 10.5 LRA 60Hz 3.7 FLA 10.0 LRA
Air Filtration	three-stage
Ambient Temperature Limits	-22° to 150°F -30° to 65°C
Stack Gas - Max.	750°F (400°C)

CONSIDERATIONS FOR CHOOSING AN OPACITY INSTALLATION SITE

PRIMARY CONSIDERATIONS FOR TRANSMISSOMETER

The primary considerations in choosing a site are accessibility, ambient environment and a location that will allow the unit to give a representative analysis of the process. Review the Federal Register in back of this section for suggestions before selecting an installation site.

1. Accessibility to the transmissometer for periodic maintenance and inspection.

2. Transmissometer Ambient Environment. Locate stack mounted portion in area within the extremes of temperatures stated in Dynatron specification -22° to 150°F (-30° to 65°C). Areas which are clean and dry are desirable. The use of the Dynatron weather covers affords protection from dirt and moisture.

3. Locate the transmissometer to avoid excessive vibration or shock. Avoid areas with condensation.

4. Locate the transmissometer more than two stack diameters from the stack exit.

AMBIENT TEMPERATURE TRANSMISSOMETER LOCATION

A. TEMPERATURE

The stack mounted weather covers have an air purge system to keep the stack isolation windows clean and also isolate the equipment from stack temperatures. This requires that the enclosures be mounted in an ambient environment area not exceeding -22° to 150°F (-30° to 65°C)per drawing 100-6358.

B. DIRT

The weather enclosure purge air systems include three stages of air filtration which consist of a debris filter, cyclone separator, and a 10 micron filter element.

The maintenance interval will be directly related to the environment. Time intervals generally vary from 2-3 months in fairly clear installations to twice a month for dirty environments.

The design of the Dynatron Purge Air System is very effective, and minimal window cleaning will be required. Installations the writer has been personally involved in show little or no dirt accumulation after 2-3 month periods. However, each installation has its own characteristics and window cleaning will be a function of stack ambient conditions and cleanliness of the purge air.

MECHANICAL INSTALLATIONS

A. Prints: 100-5954-4
100-6358
100-6356

A review of the above prints and procedures will help to produce an error free installation. However, there are two important additional points which must be observed. The beam of the instrument must be kept in the horizontal plane. The weather enclosures must be installed vertically plumb.

B. PLATFORMS

A platform or walkway must be available to obtain accessibility to the weather enclosures. The optimum condition would have the mounting flanges approximately 5 feet (1.5M) up from the floor, but in all cases, a minimum of 8 inches (203mm) from the bottom of the weather cover to the floor is required to remove the air filters. Railings and other obstructions should allow the weather cover door to swing clear as shown in "1100M Monitor Mechanical Installation", drawing #100-6358.

C. ALIGNMENT OF STACK FLANGES

Stack flange alignment is covered in drawing #100-5954-4 and is the first step in a successful installation. The final beam alignment adjustments will be cover in the Mechanical and electrical installation section.

D. SAMPLE AREA

To achieve a representative sample, the accepted practice is to have the path of the instrument directly in the centroidal area of the stack. An area should be chosen (See the Federal Register in the back of this section) where the gases are not stratified in the stack or duct. Where a bend is involved, the path should be chosen to be in the plane of the bend. Locations where large amounts of condensed water may be present should be avoided.

E. MOUNTING THE DIN CABINET CONTROL UNIT

See drawing #100-6355.

The monitor display module is housed in a DIN 43831 enclosure that is well sealed from the ambient environment. The module is designed to give information to the operator, and it should be mounted so that it is visible to the operator.

The Dynatron Monitor also has extensive self-diagnostics that are available from the module. To take advantage of these, the units should be mounted less than 5 feet (1.5M) from floor level. This permits the operator to read and/or change the switches when the chassis is pulled out.

INSTALLATION TOOL REQUIREMENTS

The following list of tools will allow proper installation and service of the Model 1100M Opacity Monitor.

All sizes are in inches,

1 - 6" Large Extension Bar, 3/8

1 - Reversible Ratchet, 3/8 Drive

1 - 7/16 Socket, 3/8 Drive

1 - 1/2 Socket, 3/8 Drive

1 - 9/16 Socket, 3/8 Drive

1 - Adjustable Wrench Max Opening 1-1/4

1 - 9/16 Open End Wrench

1 - 7/16 Open End Wrench

1 - 5/32 Allen Wrench - Standard

1 - 3/16 Blade Screwdriver - 4" Long

1 - Philips Screwdriver (Small) #2 - 4" Long

1. After sight selection and suggested platform requirements have been completed as described in Section 2, the mounting flanges for the weather covers should be installed and aligned as described on Drawing 100-5954-4. Flanges should be installed with the mounting faces on the vertical plane, if possible.

3. Mount the transmissometer and retrorefector enclosures on their respective flanges with four (4) 3/4" dia. (M 16 for Din 150 Flange) bolts and nuts (by others). A flange sealing gasket is supplied for each enclosure.

4. The air purge blowers MUST be powered up at this time to prevent stack particulate from accumulating in the nipple and air purge housing. Refer to Drawing 100-6357-1, Electrical Installation & Internal Wiring.

   a. All wiring from the control room to the transmissometer enclosure and from the retroreflector to the transmissometer enclosure should be completed at this time, refer to Drawing 100-6357.

5. Remove transmissometer, retroreflector, and stack power supply from the shipping carton and check that the serial numbers match.

   a. Cables and remote meter should be take to stack location along with the above.

6. In the transmissometer weather cover remove the 1/4" hex nuts from the 4 studs protruding from the air plenum. Slide the transmissometer forward over the studs and secure with nuts and washers.

7. Mount the remote power supply assembly on the right rail assembly with two (2) slotted screws and one (1) quarter turn fastener.

   a. Connect P-3 cable from the terminal strip to the power supply.

   b. Connect P-1 and P-2 cables from the power supply to the transmissometer.

   c. Connect the black female power cord to the stack power supply.

8. On the power supply push the screen up to expose the power supply test points. Check that the voltages marked are correct.

9. In the retroreflector weather cover remove the 1/4" hex nuts from the 4 studs protruding from the air plenum. Slide the retroreflector forward over the studs and secure with nuts and washers.

10. Mount the remote meter assembly on the right rail assembly with two (2) slotted screws and the quarter turn fastener.

BEAM ALIGNMENT PROCEDURE

1. Turn the power on to the blowers and to the stack mounted power supply. The power supply is located in the transmissometer weather cover.

2. Align the retroreflector mounting flange so that it is plumb and parallel to the 6 inch. weather cover mounting flange. Locate the 8 (eight), 9/16 inch adjusting nuts (see fig 1) until this is accomplished and lock into position.

3. At the transmissometer:
   On the top of the transmissometer power supply you will find a switch marked "Target Light". Look through the telescope and turn on the target light. You should see the target light on the retro side and the cross hairs (see figure 2) which you must align. Align by adjusting the 8 (eight), 9/16 inch adjusting nuts (see fig 1) until the alignment scope cross hairs line up with the center mark on the target.

   If the telescope cross hairs are high, adjust the top nuts outward, this will move the cross hairs & beam down.

   If they are low, adjust the bottom nuts outward.

   If they are to the left,adjust the left hand nuts outward.

   If they are to the right adjust the right hand nuts outward.

4. Be sure that all the nuts are tight when alignment has been completed.

5. SHUT OFF TARGET LIGHT ! The main bulb is turned off when the target light is on.

LAMP STEADY SWITCH

The main lamp is modulated at approximately 11 Hz with a duty cycle of 80% on time. This prevents ambient light interference. The lamp steady switch is used to turn off the modulation to the main bulb so it is easier to see the beam when looking through the telescope. This will allow you to observe the position of the actual beam around the retroreflector.
This completes the alignment.

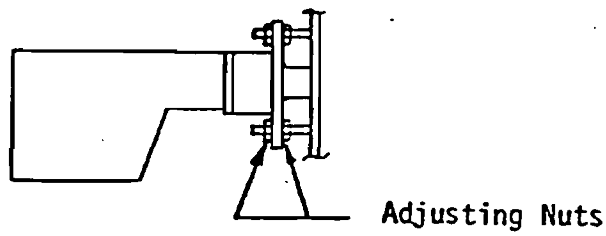


FIG. 1

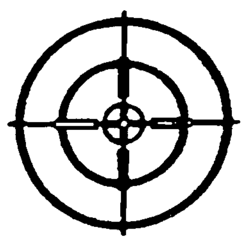


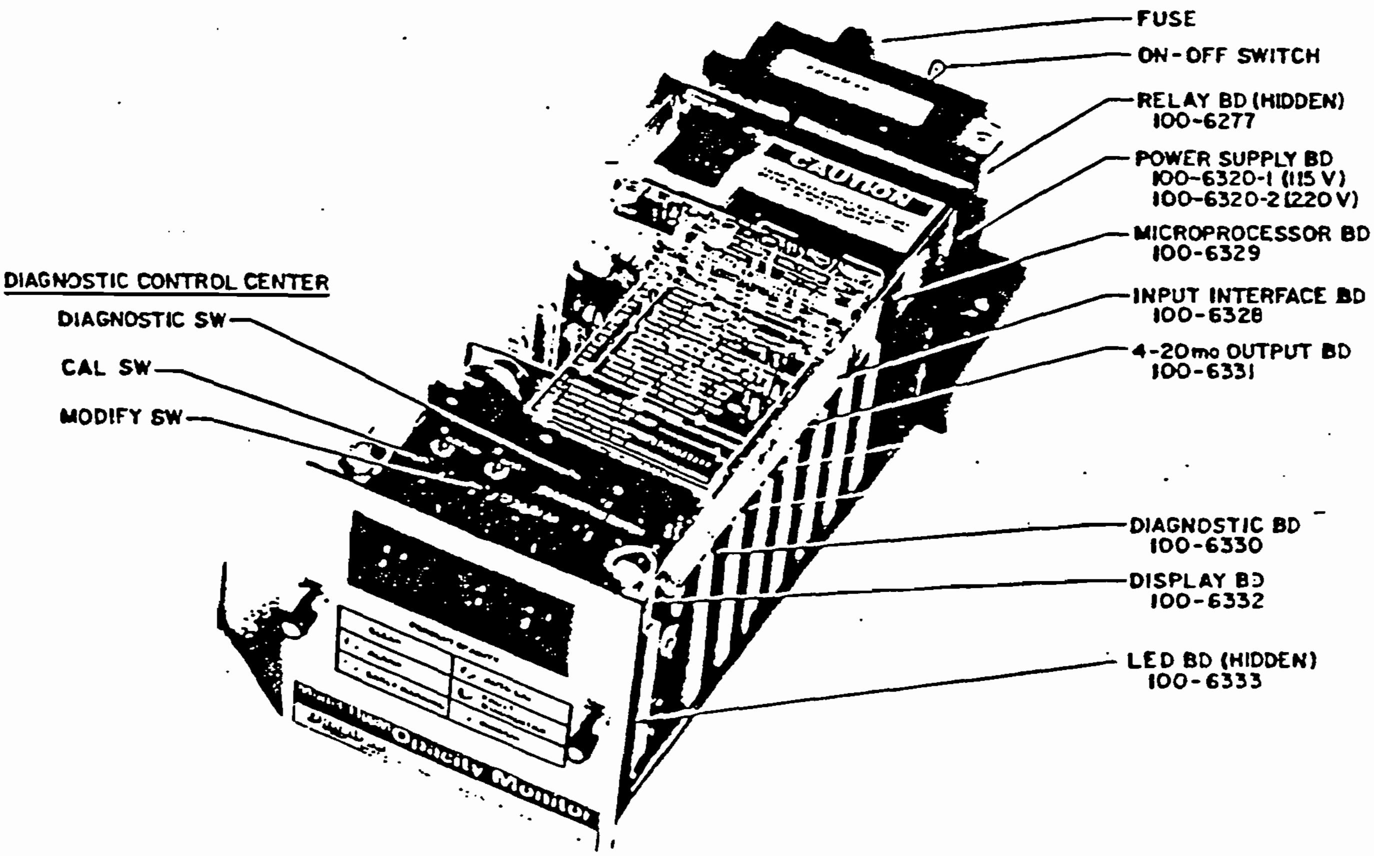
FIG. 2

CONTROL UNIT MOUNTING

1. Check the power switch to insure that it is in the "off" position. The switch is located inside the control unit.(see figure below) To access turn locks on the front panel as indicated by arrows screened on the front panel. Pull chassis toward you, but only as far as needed to get at the switch, THERE IS NO MECHANICAL STOP.

2. Mount the control monitor (see Drawing 100-6355 for mounting dimensions) in its location in the control room, and complete the wiring to the control unit output terminals located at the rear of the control unit.

3. It is strongly recommended that the control monitor be five (5) feet (1.5M) maximum from the floor to allow visual access to the diagnostic switches located inside the chassis.



Control Monitor

4.0 Installation Specifications

Install the CEMS at a location where the opacity measurements are representative of the total emissions from the affected facility. These requirements can be met as follows:

4.1 Measurement Location. Select a measurement location that is (a) downstream from all particulate control equipment, (b) where condensed water vapor is not present, (c) free of interference from ambient light (applicable only if transmissometer is responsive to ambient light), and (d) accessible in order to permit routine maintenance. Accessibility is an important criterion because easy access for lens cleaning, alignment check, calibration checks, and blower maintenance will help assure quality data.

4.2 Measurement Path. The primary concern in locating a transmissometer is determining a location of well-mixed stack gas. Two factors contribute to complete mixing of emission gases: turbulence and sufficient mixing time. The criteria listed below define conditions under which well-mixed emissions can be expected.

Select a measurement path that passes through a centroidal area equal to 25 percent of the cross section. Additional requirements or modifications must be met for certain locations as follows:

4.2.1 If the location is in a straight vertical section of stack or duct and is less than 4 equivalent diameters downstream from a bend, use a path that is in the plane defined by the upstream bend (see Figure 1-1).

4.2.2 If the location is in a straight vertical section of stack or duct and is less than 1 equivalent diameter upstream from a bend, use a path that is in the plane defined by the bend (see Figure 1-2).

4.2.3 If the location is in a straight vertical section of stack or duct and is less than 4 diameters downstream and is also less than 1 diameter upstream from a bend, use a path in the plane defined by the upstream bend (see Figure 1-3).

4.2.4 If the location is in a horizontal section of duct and is at least 4 diameters downstream from a vertical bend, use a path in the horizontal plane that is between one-third and one-half the distance up the vertical axis from the bottom of the duct (see Figure 1-4).

4.2.5 If the location is in a horizontal section of duct and is less than 4 diameters downstream from a vertical bend, use a path in the horizontal plane that is between one-half and two-thirds the distance up the vertical axis from the bottom of the duct for upward flow in the vertical section, and is between one-third and one-half the distance up the vertical axis from the bottom of the duct for downward flow (Figure 1-5).

4.3 Alternative Locations and Measurement Paths. Other locations and measurement paths may be selected by demonstrating to the Administrator that the average opacity measured at the alternative location or path is equivalent to the opacity as measured at a location meeting the criteria of Sections 4.1 and 4.2. The opacity at the alternate location is considered equivalent if location is within the range defined by the average measured opacity ± 10 percent at the location meeting the installation criteria in Section 4,2, or if the difference between the two average opacity values is less than 2 percent opacity. To conduct this demonstration, measure the opacities at the two locations or paths for a minimum period of 2 hours and compare the results. The opacity of the two locations or paths may be measured at different times but must be measured at the same process operating conditions. Alternative procedures for determining acceptable locations may be used if approved by the Administrator.

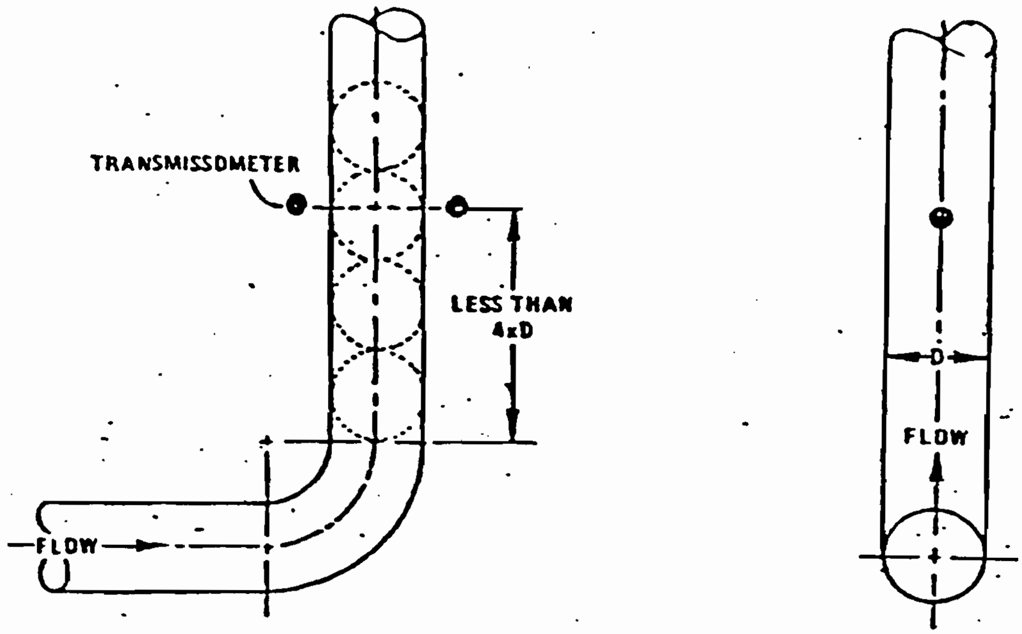


Figure 1-1. Transmissometer location downstream of a bend in a vertical stack.

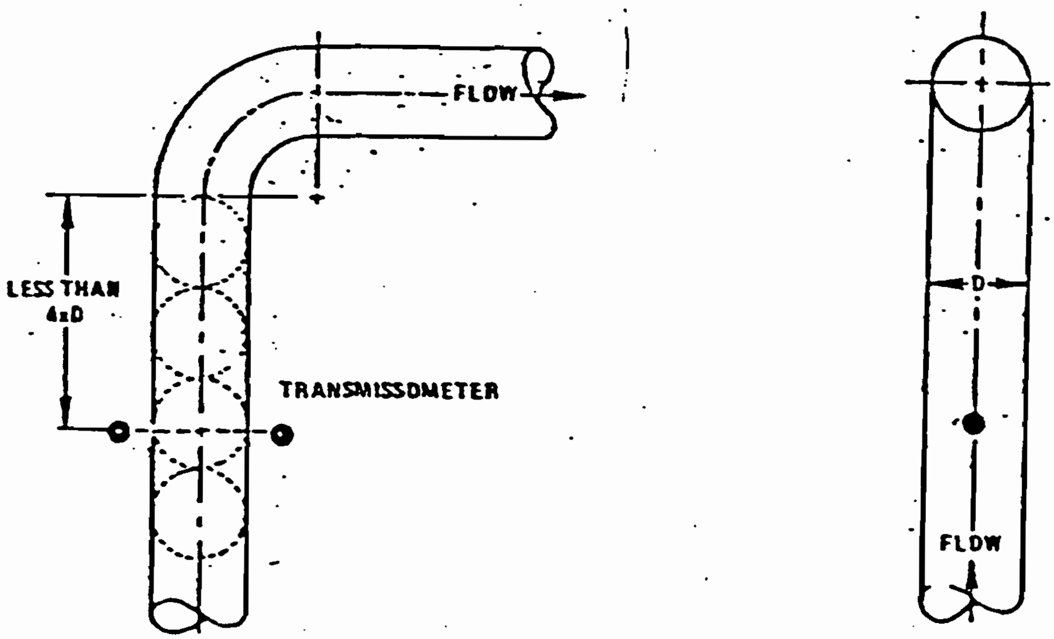


Figure 1-2. Transmissometer location upstream of a bend in a vertical stack.

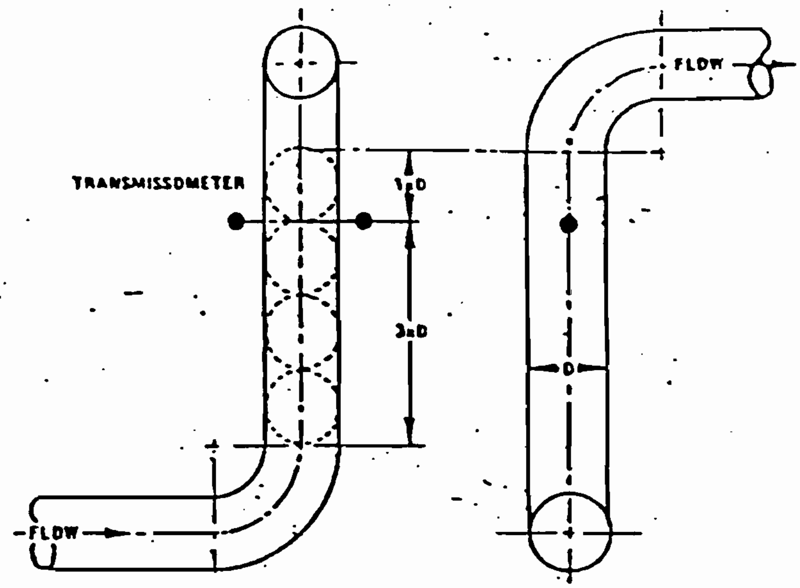


Figure 1-3. Transmissometer location between bends in a vertical stack.

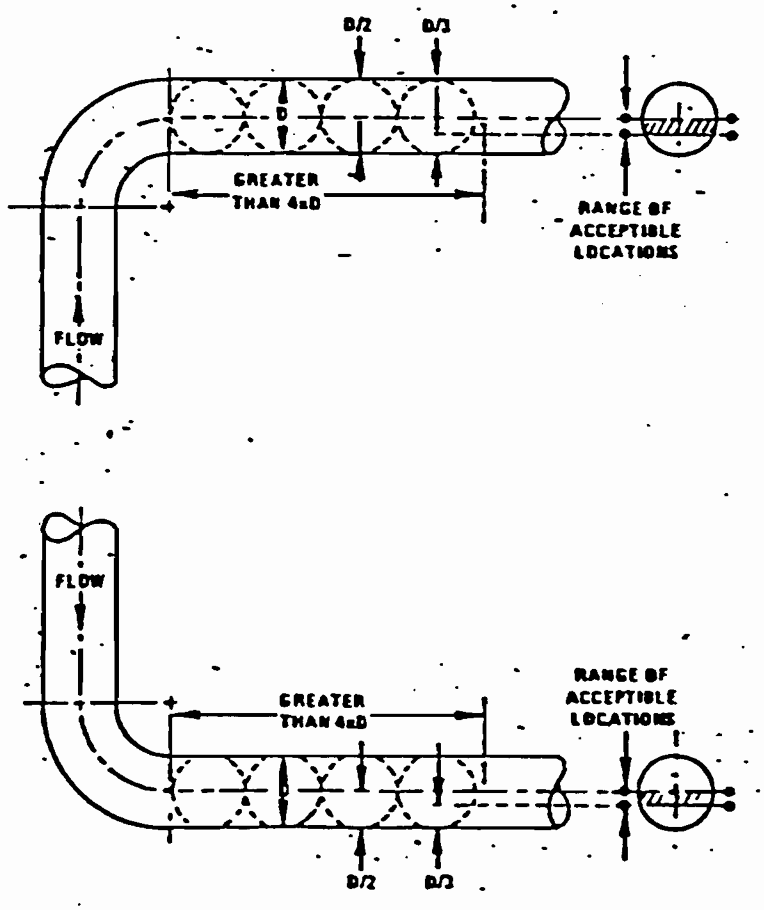
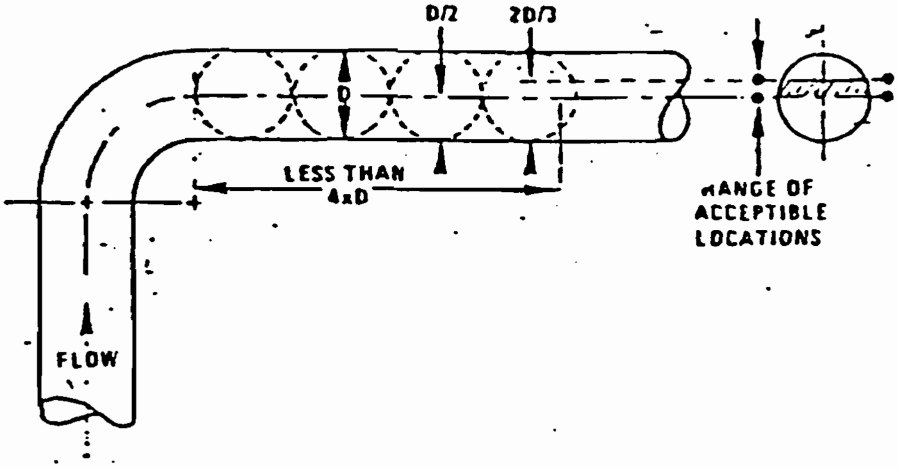


Figure 1-4. Transmissometer location greater than four diameters downstream of a vertical bend in a horizontal stack.



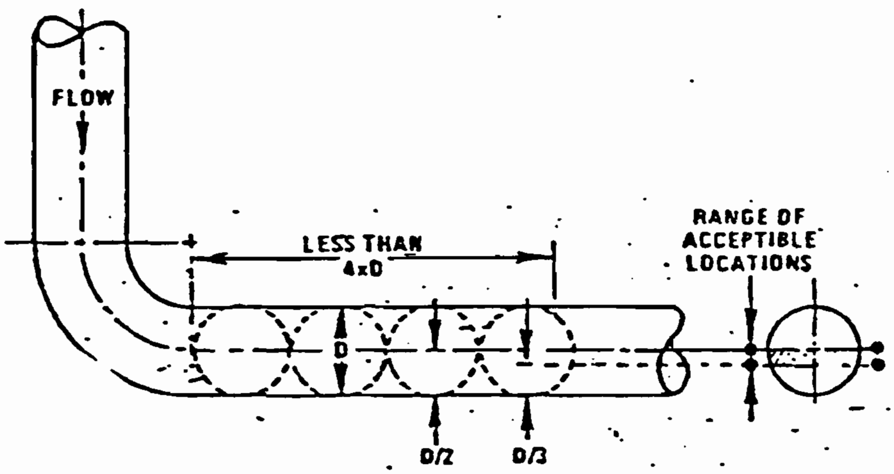


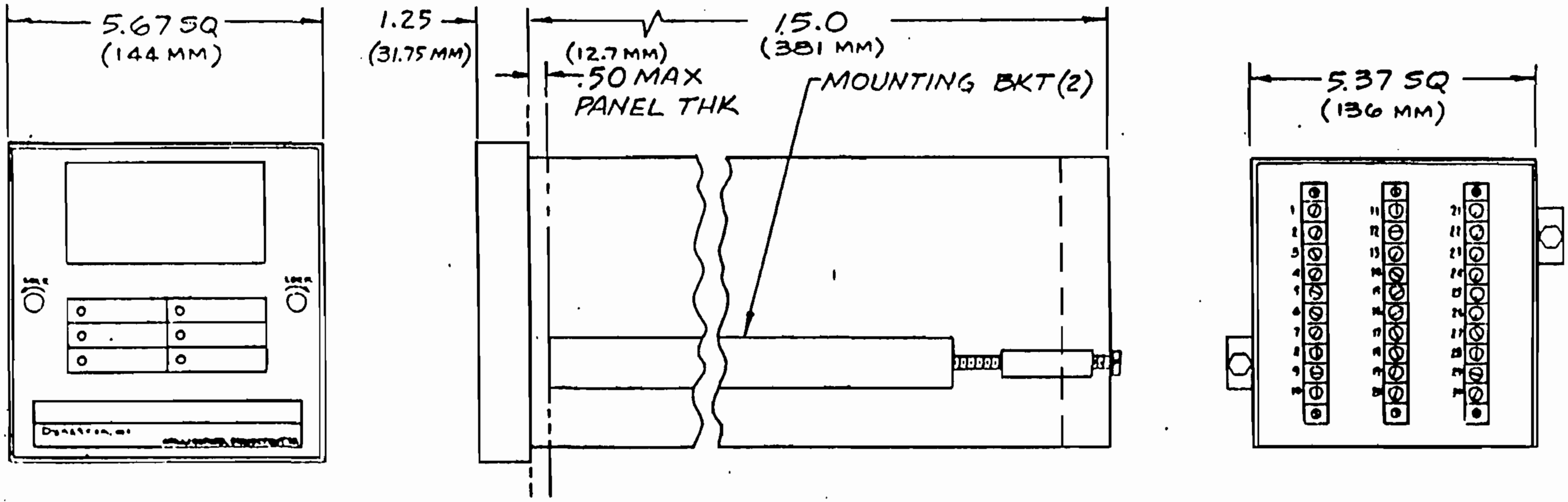
Figure 1-5. Transmissometer location less than four diameters downstream of a vertical bend in a horizontal stack.

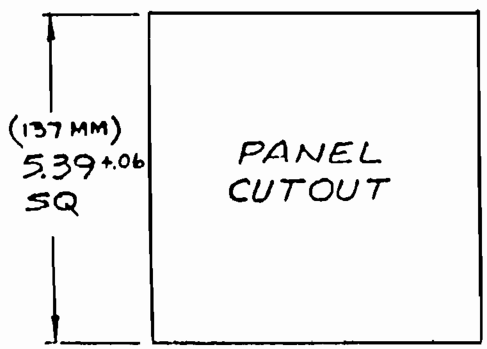
INSTALLATION DRAWINGS

MODEL 1100M OPACITY MONITOR
OUTPUT TERMINALS

1.	MEAS SIG	16.	LAMP MODULATE
2.	REF SIG	17.	MAIN LAMP CONTROL
3.	WINDOW MEAS	18.	ZERO LAMP CONTROL
4.	WINDOW REF	19.	SPAN LAMP CONTROL
5.	ANALOG GROUND	20.	DIGITAL GROUND
6.	RETROREFLECTOR AIR SWITCH	21.–22.	ALARM RELAY (N.O.)
7.	TRANSCEIVER AIR SWITCH		
8.	REMOTE SPAN	23.–24.	EARLY WARNING RELAY (N.O.)
9.	REMOTE ZERO		
10.	DIGITAL GROUND	25.–26.	CALIBRATE RELAY (N.O.)
11.	ANALOG OUTPUT #1 (+)		
12.	ANALOG OUTPUT #2 (+)	27.–28.	FAULT RELAY (N.O.)
13.	ANALOG OUTPUT #3 (+)		
14.	OUTPUT REFERENCE	29.	POWER (LINE)
15.	OUTPUT REFERENCE	30.	POWER (NEUTRAL)
			CASE POWER GROUND SCREW

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
A	REVISED	6/24/81	





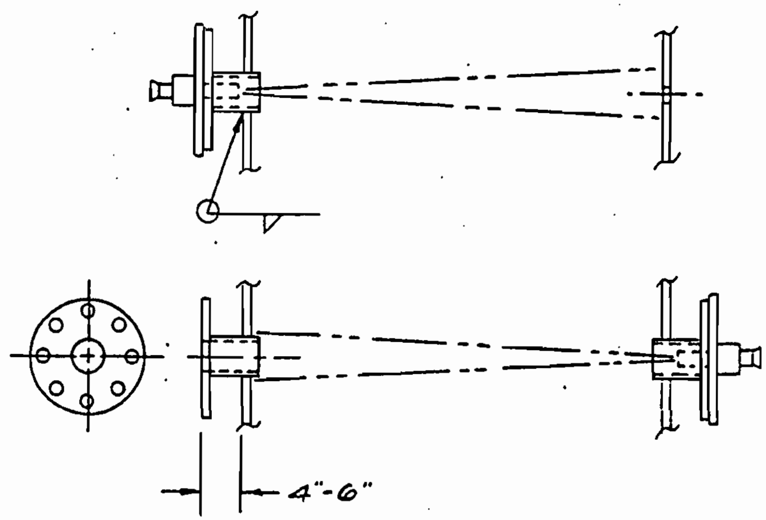
ENCLOSURE SIZE CONFORMS TO DIN 43831

TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS DEC ANGLES ± ± ±		Dynatron INC. ENERGY CONSERVATION SYSTEMS Wallingford, Connecticut 06492 U.S.A.		
APPROVALS	DATE	M SERIES REMOTE DIGITAL DISPLAY		
RMB	3/4/81			
JP	5-10-81	SIZE B	DRAWING NO. 100-6355	SCALE 1/2 SHEET 1

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
A	REVISED "INSTALLATION PROCED	10/24/85	JCS

INSTALLATION PROCEDURE - STACK FLANGES, 6", 150 LBS.

ON A DYNATRON ANALYZER/MONITOR WITH HEAT SHIELDS, THE USER IS REQUIRED TO SUPPLY AND INSTALL TWO 6", 150 LB. FLANGES DIRECTLY ACROSS FROM EACH OTHER. THE FLANGE FACES, MOUNTED ON PIPE STUBS, SHOULD BE AS CLOSE TO THE STACK WALL AS POSSIBLE, APPROXIMATELY 4" TO 6". MOUNTING HOLES MUST BE POSITIONED ON THE VERTICAL AND HORIZONTAL AXIS. UPON COMPLETION OF THE INSTALLATION, THE FLANGES MUST BE ALIGNED SO THAT TOTAL DEVIATION OF THE SOURCE FLANGE, RELATIVE TO A COMMON CENTERLINE, DOES NOT EXCEED $\pm 1^\circ$ AND THE OPPOSITE FLANGE DOES NOT EXCEED $\pm 3^\circ$. ANY DEVIATION UP TO THE PREVIOUSLY SPECIFIED LIMITS CAN BE ADJUSTED OUT DURING THE INSTALLATION AND ALIGNMENT OF THE INSTRUMENT. AN ALIGNMENT TOOL MAY BE BORROWED OR PURCHASED FROM DYNATRON TO INSURE ACCURATE ALIGNMENT.



ALIGNMENT TOOL PROCEDURE

ACCURATELY LOCATE ONE 6-5/8" DIA. HOLE (LARGE ENOUGH TO ACCEPT THE 6" PIPE) AND ANOTHER HOLE APPROXIMATELY ½" DIA., DIRECTLY ACROSS FROM EACH OTHER. ATTACH THE ALIGNMENT TOOL TO THE FLANGE/STUB ASSY. AND INSERT THE PIPE INTO THE 6-5/8" HOLE IN THE STACK WALL. ALIGN THE ASSY. WITH THE ½" DIA. HOLE ON THE OPPOSITE SIDE BY VIEWING THROUGH THE ALIGNMENT TOOL AND WELD THE PIPE IN PLACE. CARE MUST BE EXERCISED WHEN WELDING TO MAINTAIN THE ALIGNMENT.

THE ½" DIA. HOLE SHOULD NOW BE ENLARGED TO APPROXIMATELY 6-5/8" TO ACCEPT THE OTHER FLANGE/STUB ASSY. PROCEED IN THE SAME MANNER, INSTALLING THE ASSY. WITH THE ALIGNMENT TOOL ATTACHED, AND WELD IN PLACE MAINTAINING CONCENTRIC ALIGNMENT WITH THE 6" PIPE PREVIOUSLY INSTALLED ON THE OPPOSITE WALL.

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS DEC ANGLES
± ± ±

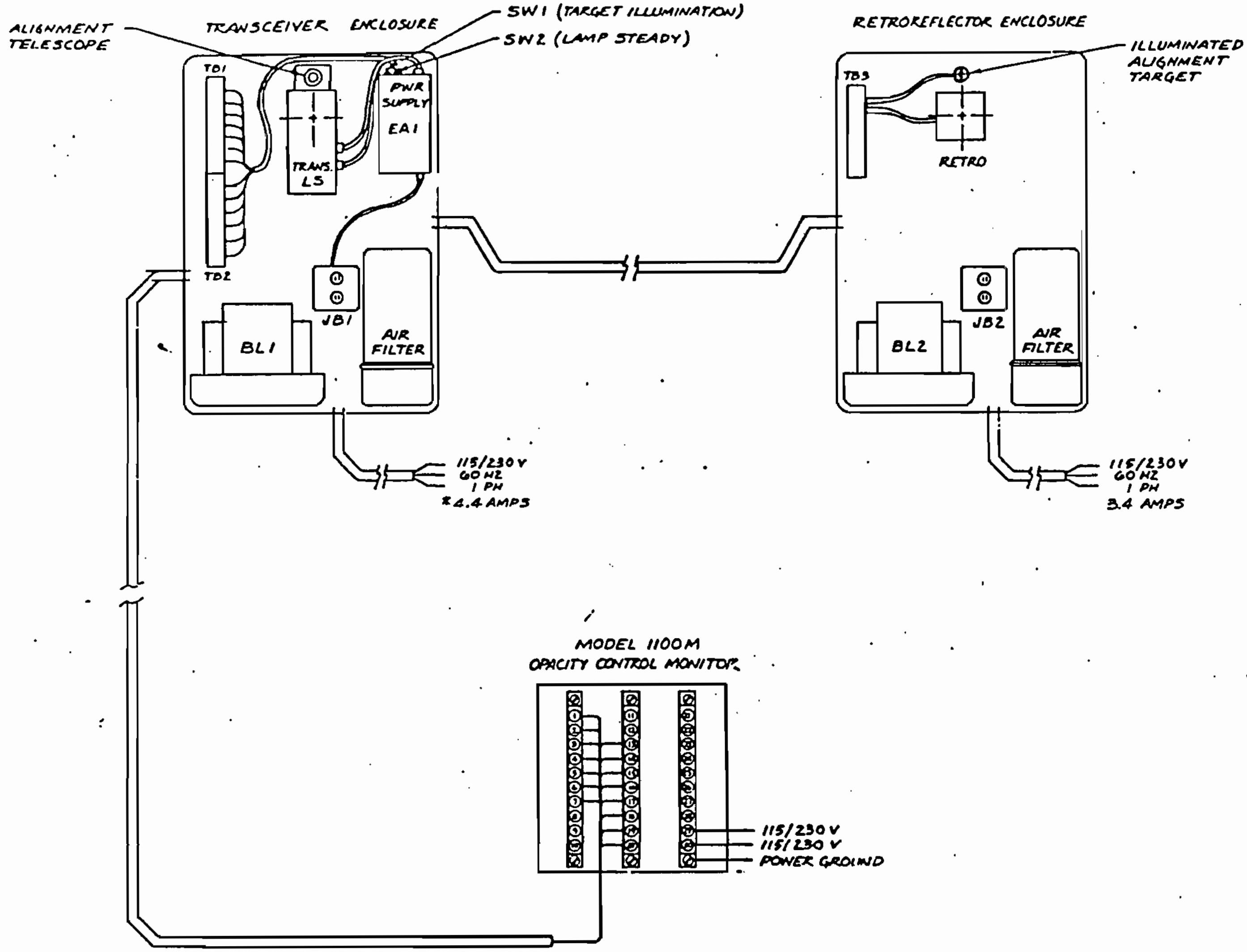
Dynatron INC.
ENERGY CONSERVATION SYSTEMS
Wallingford, Connecticut 06492 U.S.A.

APPROVALS		DATE
DRAWN	RWB	7/1/81
CHECKED	A.F.P.	8-3-81

INSTALLATION PROCEDURE 6"-150 LB STACK FLANGES

SIZE: B DRAWING NO.: 100-5954-4 SCALE: SHEET:

B	"8 SPAN WAS ZERO "9" ZERO WAS SPAN		
C	0-1 MA WAS 0-10 V		



TERMINAL DEFINITION

1 MEASUREMENT SIGNAL
2 REFERENCE SIGNAL
3 WINDOW MEASUREMENT
4 WINDOW REFERENCE
5 ANALOG GROUND
6 RETRO AIR SWITCH
7 TRANSCEIVER AIR SW.
8 SPAN COMMAND
9 ZERO COMMAND
10 DIGITAL GROUND
11 ANALOG OUT #1 INST. OPACITY 4-20 MA
12 ANALOG OUT #2 AVERAGE OPACITY 4-20 MA
13 ANALOG OUT #3 0-1 MA
14 OUTPUT REF
15 OUTPUT REF
16 LAMP MODULATE
17 MAIN LAMP CONTROL
18 ZERO LAMP CONTROL
19 SPAN LAMP CONTROL
20 DIGITAL GROUND
21, 22 } RL-3 ALARM
23, 24 } RL-4 EARLY WARN
25, 26 } RL-2 CAL
27, 28 } RL-1 FAULT
(21–28: RELAY CONTACTS N.O.)
29 115/230V
30 115/230V
⏚ - POWER GROUND

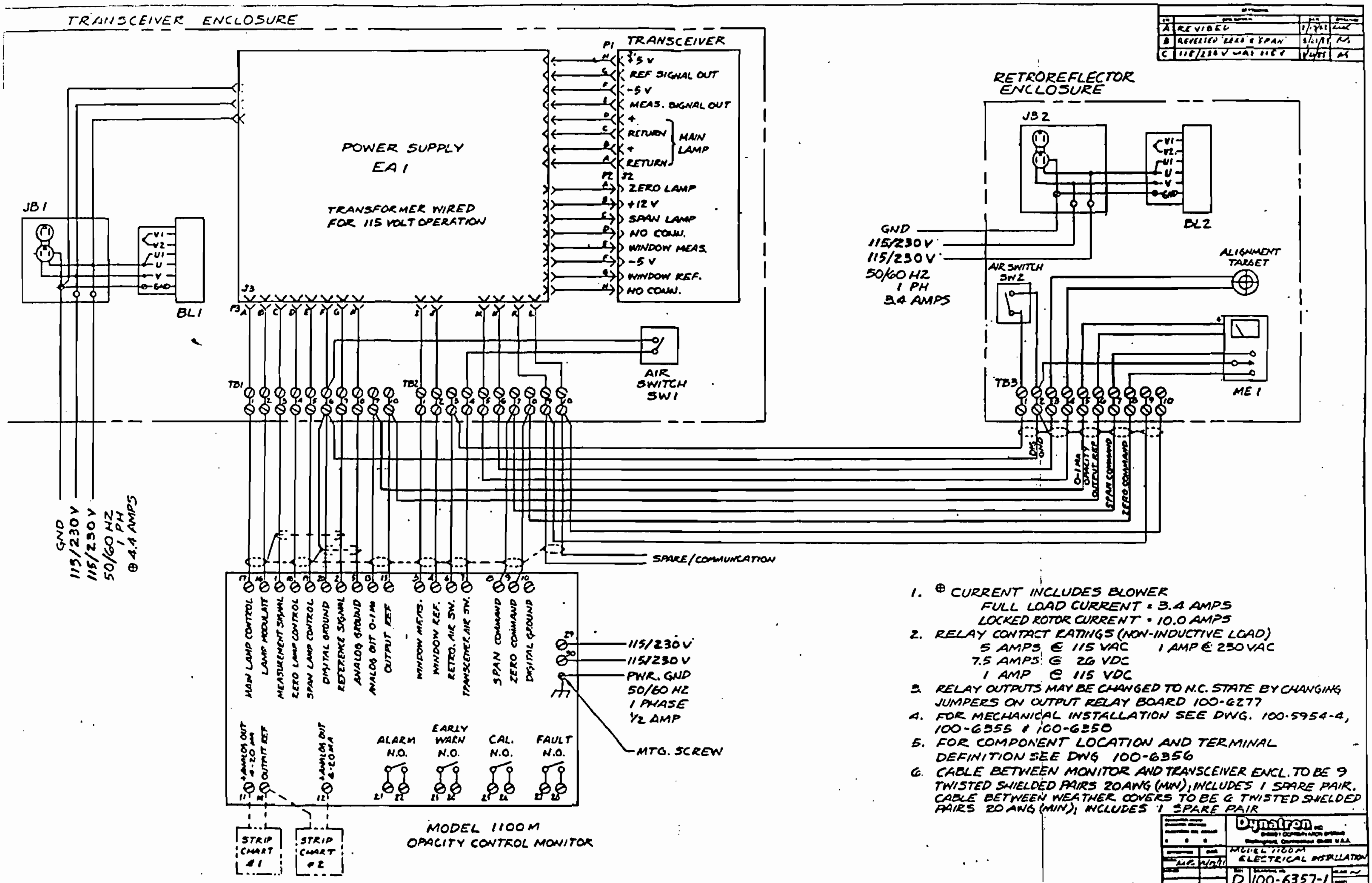
NOTES

1. * CURRENT INCLUDES BLOWER
FULL LOAD CURRENT • 3.4 AMPS
LOCKED ROTOR CURRENT • 10.0 AMPS
2. RELAY CONTACT RATINGS (NONINDUCTIVE LOAD):
5 AMPS @ 115 VAC 1 AMP @ 280 VAC
7.5 AMPS @ 26 VDC
1 AMP @ 115 VDC
3. RELAY OUTPUTS MAY BE CHANGED TO N.C. STATE BY CHANGING JUMPERS ON OUTPUT RELAY BOARD 100-6277
4. FOR MECHANICAL INSTALLATION SEE DWG. 100-5954-4, 100-6355
5. FOR ELECTRICAL INSTALLATION AND INTERNAL WIRING SEE DWG. 100-6357 & 100-6358

Dynatron

MODEL 1100M ELECTRICAL TERMINAL & COMPONENT LOCATION

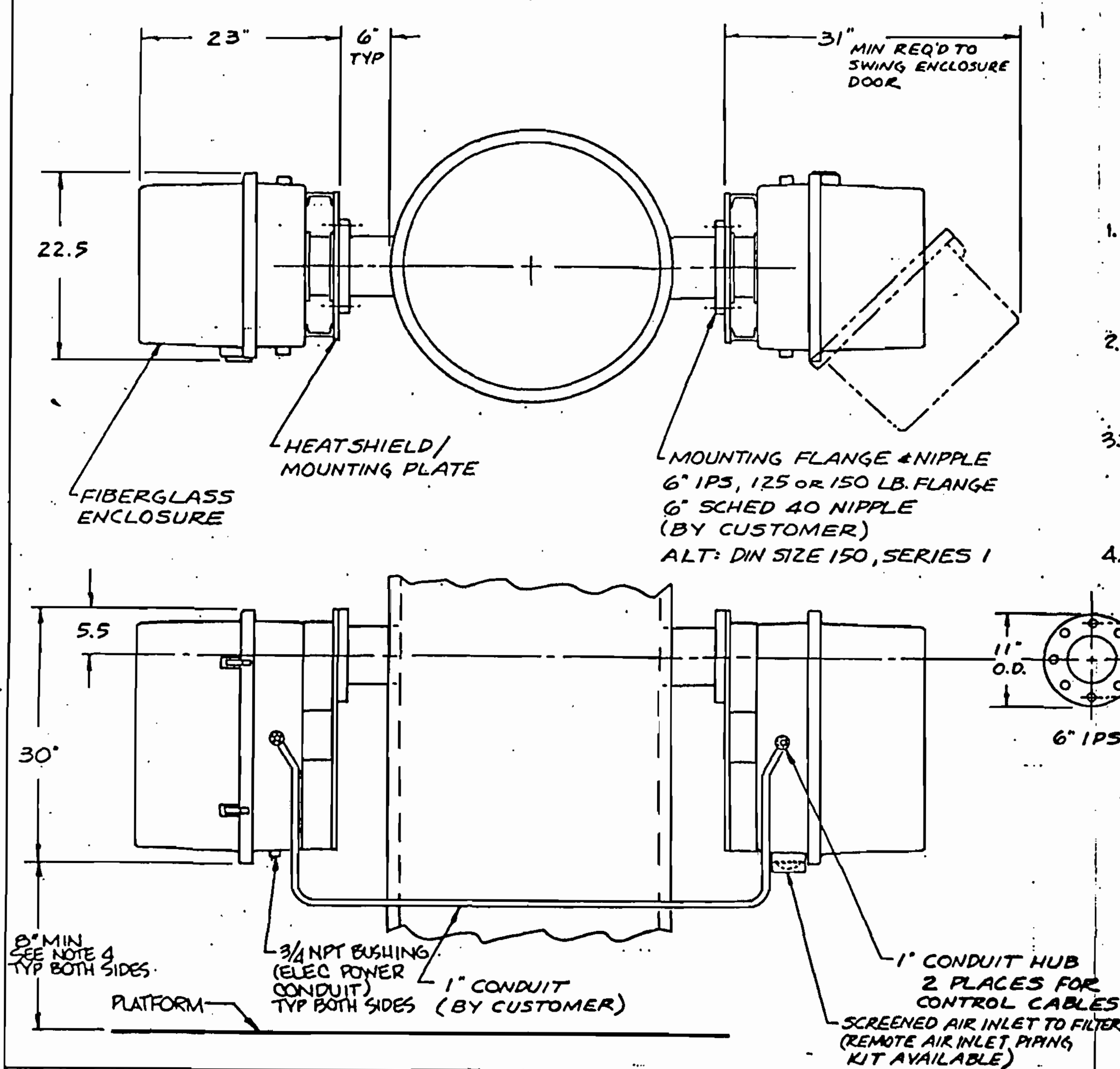
D 100-6356



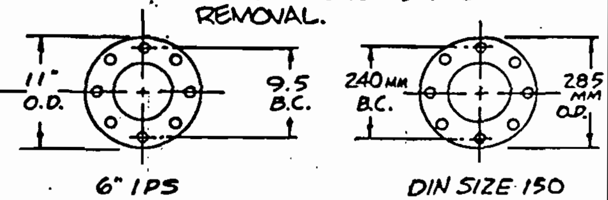
1. ⊕ CURRENT INCLUDES BLOWER
   FULL LOAD CURRENT = 3.4 AMPS
   LOCKED ROTOR CURRENT = 10.0 AMPS
2. RELAY CONTACT RATINGS (NON-INDUCTIVE LOAD)
   5 AMPS @ 115 VAC 1 AMP @ 230 VAC
   7.5 AMPS @ 26 VDC
   1 AMP @ 115 VDC
3. RELAY OUTPUTS MAY BE CHANGED TO N.C. STATE BY CHANGING JUMPERS ON OUTPUT RELAY BOARD 100-6277
4. FOR MECHANICAL INSTALLATION SEE DWG. 100-5954-4, 100-6355 & 100-6358
5. FOR COMPONENT LOCATION AND TERMINAL DEFINITION SEE DWG 100-6356
6. CABLE BETWEEN MONITOR AND TRANSCEIVER ENCL. TO BE 9 TWISTED SHIELDED PAIRS 20AWG (MIN); INCLUDES 1 SPARE PAIR. CABLE BETWEEN WEATHER COVERS TO BE 6 TWISTED SHIELDED PAIRS 20 AWG (MIN); INCLUDES 1 SPARE PAIR

Dynatron
MODEL 1100M ELECTRICAL INSTALLATION
D 100-6357-1

A	REVISED	1/14/70	
B	CHG'D PER CN#3	10/28/07	



1. INSTALL FLANGES & NIPPLES TO STACK CONCENTRIC AND PARALLEL WITH EACH OTHER WITH BOLT PATTERN POSITION AS SHOWN.
2. MOUNT ENCLOSURES WITH FOUR (4) 3/4" DIA BOLTS AND NUTS (BY CUSTOMER). ALT: M16 FOR DIN FLANGE.
3. ELECTRICAL POWER TO BLOWERS MUST BE ENERGIZED IMMEDIATELY AFTER INSTALLATION. POWER REQUIREMENTS PER CUSTOMER P.O.
4. MINIMUM CLEARANCE REQUIRED FOR AIR PURGE SYSTEM FILTER REMOVAL.



MOUNTING FLANGE HOLE ORIENTATION

Dynatron INC.
ENERGY CONSERVATION SYSTEMS
Wallingford, Connecticut U.S.A.

AIR PURGE WEATHER COVER MECHANICAL INSTALLATION

5/1/81

C 100-6358

SECTION 3

Operating Instructions

1100M CONTROL UNIT EXPLANATIONS

SYSTEM OUTPUTS

The opacity control unit has digital indicator, analog current outputs, and contact closures.

1. Digital display for opacity, optical density, transmittance, and selected variables.
2. A CLEAR STACK indicator lamp.
3. An EARLY WARNING indicator lamp and associated contact closure.
4. An ALARM indicator lamp and associated contact closure.
5. A CALIBRATION indicator lamp and associated contact closure.
6. A DIRTY WINDOW indicator lamp.
7. A CALIBRATION MODE indicator lamp.
8. A FAULT indicator lamp and associated contact closure.
9. Primary current loop (analog output #1) terminal 11.
10. Secondary current loop (analog output #2) terminal 12.
11. Remote meter (0-1ma), analog output #3) terminal 13.

USER CONTROLS

The user controls are located internally to the display chassis and are not frequently accessed. These controls consist of a 2-digit diagnostic switch, an associated UP/DOWN command switch, and a separate CAL command zero or span switch.

The DIGI SWITCH (diagnostic switch) is used to control a group of variables. The variables assigned as factory settings are protected from casual change by a "password" number. This number must be set to the proper value before the computer will allow "factory" variables to change. The protected variables are those locations with a digi switch location 16 or greater.

The variables will be displayed as a 2-digit number (00 to 102). An increase command will saturate at the highest allowable value (102). A decrease command will saturate at zero (00). (See function list for details, section 3-6.)

MEMORY REFRESH PROCEDURE

A special escape sequence has been implemented for use in those cases where the protected ram data becomes scrambled (due to battery failure, part replacement, etc.). This operation will restore all variables to a default setting. The sequence is performed by the MEMORY REFRESH PROCEDURE (see section 5-1).

The general variable inspect/modify method involves setting the DIGI SWITCH to the proper location number, inspecting the current value on the PANEL DIGITS, and increasing (decreasing) it via the UP/DOWN command switch. The UP/DOWN switch, when actuated, will cause the variable to immediately step to the next logical count. If the switch is held in the actuated position for about 0.5 seconds, the value will start incrementing at approximately. a 4Hz rate. The user can then hold the switch until the required setting is achieved.

Stack Exit Correlation

Two combinational controls are available to perform the necessary correction to the measured signal for the particular installation. These two controls for LX/LT form a decimal exponent argument for use in modifying the measurement. The practical range on the controls is from about 10 to 0.1. An exponent of 2.5 would be entered as a 2 and a 50. An exponent of .45 would be entered as a 00 and a 45. The LX/LT control has a resolution of 0.01.

AUTO CALIBRATION

The variables directly involved with the auto calibration process include eight controls and nine informational displays. The controls set the repeat time, duration, average time, and measurement correction parameters.

Calibration Timing

Three controls are used to set the repeat time, calibration average time, and the calibration duration. The repeat time is controlled in integer hours from 1 to 102. This time is the elapsed time between automatic calibration intervals.

The calibration duration is controlled in integer minutes from 1 to 102. This duration is the amount of time spent first in ZERO mode and then in SPAN mode. An actual calibration duration cycle will be twice the time shown. The calibration average time is controlled in integer seconds from 1 to 102. This time control effects the stability of the calibration measurement (more time means more stability). A calibration measurement is performed every "average time". In the usual condition, an "average time" is six seconds long. Therefore, for a duration of one minute, there will be six independent measurements of zero and span performed every calibration cycle.

USER CONTROLS EXPLAINED

This section explains the function and usage of the various user controls.

Display Selected Variable

This setting of 00 in the digi switches allows the panel digits to display the assigned measurement parameter. This is also the only setting where the "HELP" alarm signal is displayed.

ALARM/WARNING

Five control variables are used to set the operating parameters used to determine if an ALARM or WARNING or CLEAR condition exist. The sense mode sets which average is used in the determination (fast average or slow average). Since the averages have discreet time intervals, the ALARM/WARNING checks also are performed at the same discreet time intervals. The notation "EVENTS" is used to specify the occurrence of a test failure at the time intervals mentioned above.

Both ALARM and WARNING have a pair of controls to set the trip limit and to set the number of consecutive "EVENTS" that must occur to cause the condition to light the appropriate lamp. Any time a single "pass" event occurs, the ALARM/WARNING condition will be cleared. The CLEAR lamp will activate only if both ALARM and WARNING are false.

Three time related controls are available. It is possible to set them where the duration time is less than the average time. Make sure the duration is greater than the average time. The calibration output will occur at discreet average time intervals. The completion of a duration interval will discard any data collected during the final partial average cycle.

Calibration Nominal and Actual Values

Two controls exist to set the "zero" and "span" nominal values. Two informational displays exist to show the last measured "zero" and "span". The difference between nominal and measured value is used in the automatic measurement correction described below.

Calibration Correction

A control variable is available to allow the measurement system to automatically correct for minor drifts in the system calibration. The correction involves adjusting the BIAS and SCALE factors based on the size of the calculated error and the percentage correction per measurement set by the variable.

When the system is in "ZERO" mode, any errors are assigned to the transmittance BIAS control and appropriate corrections are accumulated in the control BIAS and MINOR BIAS control variables. The MINOR BIAS control is used to accumulate small errors until they are large enough to modify the BIAS variable. When the system is in "SPAN" mode, any errors are assigned to the transmittance SCALE control and appropriate corrections are accumulated in the control SCALE and MINOR SCALE control variables. The MINOR SCALE control is used to accumulate small errors until they are large enough to modify the SCALE variable.

Since the errors cannot be simply separated between BIAS and SCALE, the error correction needs to iterate to converse. (Separation would be possible only in the case where ZERO was actually 0.) If auto correction is desired, this control can be set non-zero. The actual percentage correction per iteration is approximately the indicated value of the auto-correction variable. Note that the correction will occur once per measurement average time and a 60-second interval contains six measurements.

Bias and Scale Factors

Two controls are available for use in manually (and automatically) adjusting the system calibration. These controls add in a static bias term and modify the gain of the primary transmittance measurement. These controls are designed to allow both an increase and a decrease in the control variable. The controls are neutral when they indicate 50. An indication of zero is maximum decrease in the measurement. An indication of 100 is maximum increase in the variable. Each control has a range of approximately $\pm$ 20%. Note that the automatic correction has the capability of adjusting the controls beyond the user range of 0 to 102. The measurement is clamped at both zero and 100% (transmittance has an exceptional range extension to 102%). These are factory set and should not normally have to be altered.

Display Recovery Upon Calibration Termination

Five display variables are assigned to hold the output reading just prior to start of the calibration cycle. These readings are restored to the five output functions (DPM, 1st current output, 2nd current output, 0-1ma output, and alarms) immediately after completion of a calibration cycle.

Power Supply Validation

A display location is assigned to show the voltage measured on channel 7 of the ADC multiplexer. This display is adjusted to indicate 100 when the voltage is five volts. This point is connected to an accurate five volt power point. The signal is passed through op-amps that are powered by the ± 15 volt supplies. An indication of 100, therefore, validates all three power supplies.

Signal Reference Level Control and Display

Four variables are assigned to the reference signal for use in validating, displaying, and possibly controlling the signal reference level. The variables include one reference signal operating level display, two controls to set the allowable boundaries on the reference level, and a control to set the programmable gain amplifier for the reference signal.

Window Measurement and Validation

Seven variables are assigned to the measurement and validation of the test head dirty window detectors. Three displays are assigned to show the current window measurement value, the current window reference value, and the absolute magnitude of the difference of measurement to window reference. The measurement is equal to the window reference when the display shows zero. The window tests are performed at the user entered repeat time, location 36. This is also the time when the reference signal value and the power supply tests are performed. One control is used to tilt the initial window measured difference to achieve a zero display. Another control is used to set the limit of acceptable difference. Two controls are used to set the PGA level for the window signals.

Timer Controls

Three variables are assigned to setting the time of day and controlling the instant at which the various repeat times for the cyclic variables occur.

The three control variables are countdowns of the seconds, minutes, and hours remaining in the current day. These control variables can be adjusted to set the system time. Note that the internal cyclic variable can be triggered by running the appropriate time variable to zero and waiting for it to reset. The appropriate time variable is one unit smaller than the one of interest. That is, to speed up an hour timer, run the minute display to zero. To speed up a minute timer, run the second display to zero. The second timer cannot be forced faster.

UP/DOWN Change Rate

One control is assigned to set the speed at which the up/down switch changes variables. This control is based on 90 msec. time increments. Ninety msec. is the fastest rate possible, and increasing this variable will slow speed down in 90 msec. steps.

LAMP CONTROL

The transmissometer is normally located some distance from the control chassis. There is the potential of significant noise present on the measurement signal. A signal discrimination method is necessary to separate the signal from any noise. The signal generation method involves modulating the lamp and then performing a cross-correlation between the reference signal and the measured signal.

The lamp modulation algorithm consists of applying an 11Hz fixed frequency square wave with an 80% on-duty cycle.

DC EXTRACTION

The reference and measurement signals are uni-polar consisting of a DC term with a waveform approximating an integrating square wave of about 50% p-p height. Additionally, the measurement signal contains "noise".

The correlation technique used would pass any common DC term to the output. This DC term must be removed.

The system used to remove the DC term involves performing a linear running average on the reference signal and then subtracting this average from the instantaneous reference. The result then can be considered to be an "AC" signal.

SIGNAL EXTRACTION

The return signal can contain noise. Our noise rejection is based on the following assumptions.

1. The master reference will be the return reference signal. Use of this signal means we don't have to concern ourselves with any time delay involved in modulating the lamp.

2. The signal detectors are silicon. They are inherently fast compared to the lamp modulation frequency, and they will be matched. Therefore, we will assume the response times are identical.

3. The signal does not change appreciably over a one-second interval.

4. The DC extraction described above will remove any bias term.

Given the above constraints, we will perform a cross-correlation between the raw reference and the measurement signals by integrating the product of these signals over a one-second time interval and normalizing the output by effectively dividing by the time period.

$$XCOR = \frac{1}{N} \sum_{0}^{N} R*M$$

This cross-correlation method has the effect of beating the true signal down to DC and moving all noise terms to some AC frequency. The integration represents a optimal method to remove the AC terms (especially if the integration time can be picked to synchronously enhance the true signal and de-emphasize unwanted terms). See "Principles of Communication Engineering", Wozencroft and Jacobs John Wiley Sons, Inc., 1965, Chapter 4, "Optimum Receiver Principles".

We must also calculate the auto-correlation of the reference signal.

$$ACOR = \frac{1}{N} \sum_{0}^{N} R*R$$

The sampling rate should be at least ten times the input signal frequency. We have selected the number of samples per measurement frame to reduce the fractional part of input frequency periods which will reduce the uncertainty associated with residual cycles.

We avoid synchronizing to the 60Hz power both in the signal frequency and in the sampling frequency.

The actual sampling frequency is not important as long as we faithfully follow the signal extraction equation shown above.

ENGINEERING CALCULATIONS

Basic Equations

The following equations are used to get the interesting parameters.

T_x	=	(meas/ref) (L_x/L_t)	Transmittance double path = (single path)^2 .
O_x	=	$(1-T_x)*100\%$	Opacity
O_{dx}	=	$-\log(T_x)$	Optical density
O_{dx}	=	$(L_x/L_t)\log(\text{meas/ref})$	Optical density

Primary Operation

The basic measure we make is related to meas*ref. We must translate this into a meas/ref function. The ratio is found by dividing the cross-correlation by the reference auto-correlation (M/R == (M*R)/(R*R)). This operation will produce a value between 0.0 and 1.0.

$$T_{xi} = \{(XCOR/ACOR)*(1/GAIN)\}\ (L_x/L_t)$$

The above equation shows how we calculate the instantaneous one-second transmittance. This calculation is the basis for all measurements.

The fast and slow averages are obtained by a gated integration of a set of instantaneous measures, normalized by the number of samples, over a time period equal to the average.

$$Txl = \frac{1}{N}\sum_{0}^{N} Txi$$

N = 60*(slow AVERAGE TIME)

$$Txs = \frac{1}{M}\sum_{0}^{M} Txi$$

M = (fast AVERAGE TIME)

START-UP PROCEDURE
AND
COMMISSIONING

The following tasks must be completed before start-up can be done and before the scheduled arrival date of a factory serviceman.

1. Power available at the installation site.

2. Required electrical cables in place between the stack and control unit.

3. Required electrical cables in place between the weather covers.

4. Flanges installed and aligned.

5. Transmissometer and retroreflector installed.

6. Weather covers and blowers installed and running.

7. Remote meter provided, installed.

8. All interconnecting wiring between control unit and terminal strips provided in the weather covers.

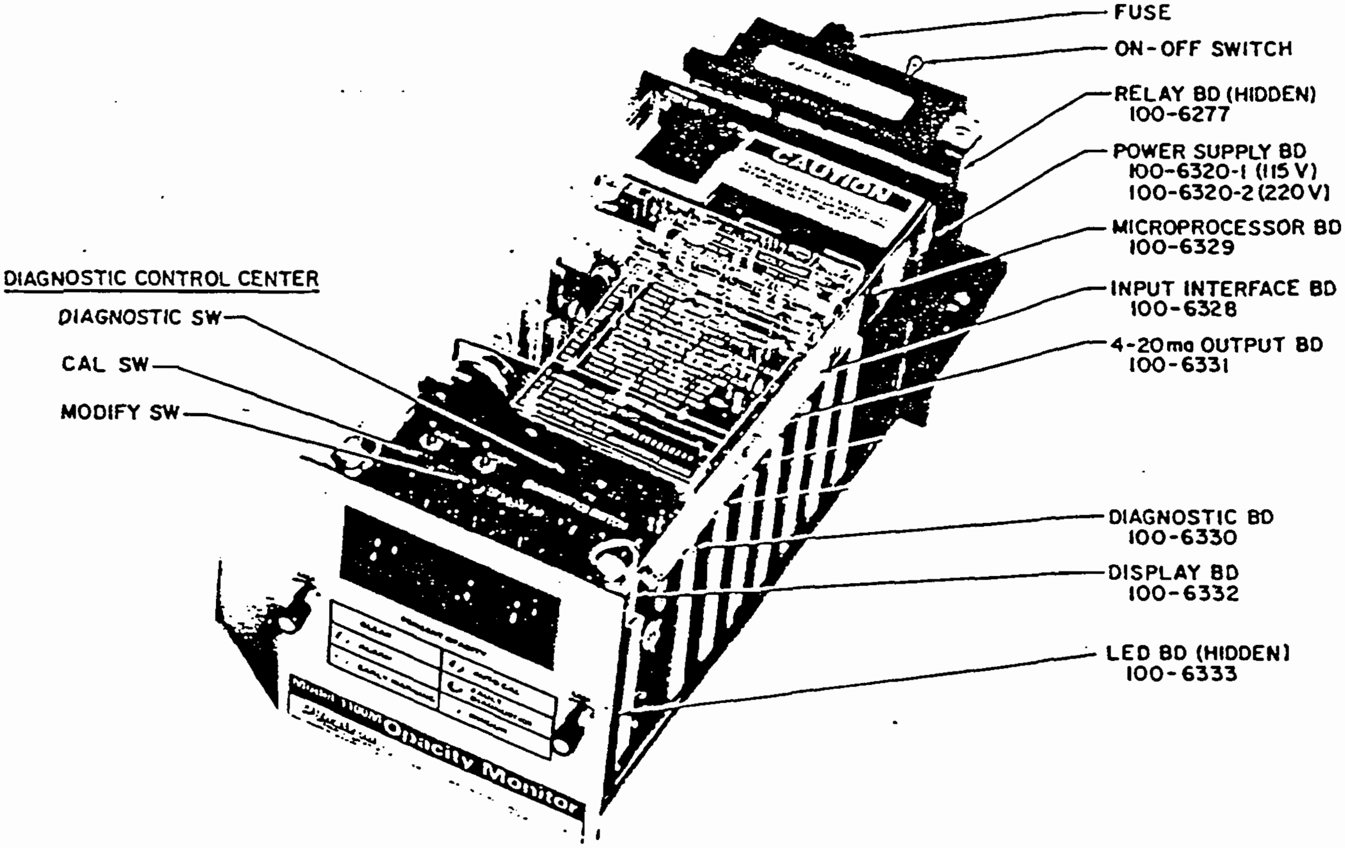
9. Recorder installed and interconnected.

Start-Up

It is assumed that the mechanical and electrical installation procedure has been completed and all cabling is correct.

It is suggested that you read "Control Unit Explanations" in Section 3 before attempting start-up to familiarize yourself with the control unit's operation.

1. Turn on power to the micro chassis at the control panel by releasing the two locking knobs on the front panel and sliding the chassis outward far enough to reach the on-off switch (Page 3-11, Fig. 1). Care should be taken to prevent disengaging the chassis guide rails from the case. Apply power to the micro.



Control Monitor

Fig. 1

2. Allow the unit approximately 15 minutes for warm-up before addressing any locations. NOTE: Valid readings cannot be taken before this waiting period.

3. In order to access information from the micro, we will use the front display and the diagnostics switch, which is located on the diagnostics board. NOTE: See the clear plastic card cover for board and switch locations. A complete list is in Sec. 3, Page 17

4. The diagnostics switch (see Fig. 1) consists of two thumbwheels each having numbers from 0-9. Minimum and maximum positions are: 00 and 99. The unit's column is closest to the operator.

5. We will now check the control unit's power supplies.

   Turn the thumbwheels until "13" shows on the diagnostics switch. Looking at the digital display, 100 ± 2 should be showing. This indication assures us that the +5 and ± 15 supplies of the control unit are correct.

6. The micro's factory selected values, which are located in the "Customer Information" sheets located in the front of this manual, will now be checked and changed, if needed.

   NOTE: If any location after 16 has to be changed, a "password" must be entered in Location 15 first. This password is the number "12". Enter 15 on the diagnostic switch, and use the "Increase/Decrease" switch to change the value to "12".

   Any value from 16-99 can now be changed if necessary. After completing all value changes, use the "Increase/Decrease" switch to bring Location 15 to 00. This "lockout" feature reduces the possibility of unauthorized personnel changing a field or factory selected value. Those operator locations 01-14 cannot be locked out.

   Run through the list in the customer information sheet and note if any factory values have changed. If any values are different than factory, change them to meet factory specifications by entering the listed value with the increase/decrease switch.

7. Turning your attention to the front panel, check to see if the "Dirty Window" or "Fault Diagnostics" LED's are on.

A. If the "Dirty Window" alarm is on, DO NOT TAKE ANY ACTION NOW.

B. If the "Fault" alarm is on, enter "14" on the diagnostic switch, and check digital display for the reason code. NOTE: Reason code terminology is located on the plastic card cover, directly above the diagnostics switch. If the code indicates an air flow switch problem, note which one is at fault (i.e., light source or retroreflector side). DO NOT troubleshoot at this point, because we still have to perform the stack start-up, which should clear any dirty window or air flow problems.

8. Stack Start-Up

A. The operator should take with him the required tool list, as described in Section 2, plus a digital multi-meter (Fluke Model No. 8000A or equivalent), this manual, and a clean cloth for slide cleaning.

B. At the stack location, perform the weather cover/blower preventive maintenance procedure, as outlined in Section 4, and also the air flow switch adjustment, as described below. NOTE: Recall which A.F. switch was defective from fault code!

C. Retro and Transmissometer Air Flow Switch Adjustment Procedure

This must be done with blowers and filters in good working condition and under normal operating conditions.

1.) Remove the switch leads on terminal strips TB1.6 & TB2.4 for transmissometer and 1 & 2 for retro (see Drawing 100-6357) and connect an ohmmeter to the leads. Remove the two screws that secure the air flow switch to the plenum and remove switch from plenum but leave the hose attached. Block the screw holes with electrical tape. Cover the air inlet with a piece of paper to significantly reduce the air flow. Now turn the adjustment screw located on the plenum side of the switch counterclockwise until the switch just opens.

2.) Observe the ohm meter with the switch in the plenum. It will be completely open. Now, you must turn the adjustment screw clockwise until the switch is intermittently closed when placed in the plenum.

3.) Remove the paper and confirm the switch is now completely closed. If the switch is correctly adjusted it will intermittenly open when the air inlet is covered and be completely closed when the inlet is uncovered.

4.) Remove tape and replace cover plate and mounting screws.

D. <u>Stack-Mounted Power Supply</u>

This supply is located directly above the black air filter canister. Check the supply voltage on the stack-mounted power supply by sliding the perforated metal screen upward and inserting your voltmeter leads into the appropriate test jacks. The supplies should be within ±200mv. Slide the screen into place.

E. Perform a beam alignment as outlined in Section 2.

F. Repeat A.F. switch adjustment and blower/weather cover checks on the retroreflector side of the stack.

G. The stack start-up is now complete. The operator can return to the control room.

9. Looking at the micro front panel, assure that all alarms are off. If dirty window is still on, do the following:

A. You should have cleaned both the transmissometer and retro slides, and dirty window detector in previous steps. If not, you must do it now.

B. Set Location 38 to 50.

C. Allow 6 minutes for control unit to update new levels.

D. 1.) Record the value in digi-switch Location 40.

2.) Record the value in digi-switch Location 42.

E. 1.) If location 40 is GREATER THAN 42, INCREASE the value in Location 38 by the amount found in Location 10.

2.) If Location 40 is LESS THAN 42, DECREASE the value in Location 38 by the value found in Location 10.

F. Select window alarm level by entering in Location 37 one count for approximately every 4% dirt accumulation limit desired.

G. Allow 6 minutes for control unit to update and clear alarm and turn off the dirty window L.E.D. on the front panel.

10. The final step in this procedure will be the changing of alarm and early warning levels, if so desired, zero/span calibration cycle rate, and a zero/span cycle check.

11. If a change is to be made to the early warning or alarm functions, enter their locations on the digi-switch and use the increase/decrease switch to change the levels.

Example: If you desire the early warning alarm at 5% opacity, enter 01 on digi-switch and use increase/decrease switch to change the value to 05. You can change alarm in the same way, but the alarm set point must always be higher than the early warning.

A. To set the time delay, go to the proper location (see function list or screen on plastic cover) and change the value to the number of seconds of delay desired. If a time delay of more than 102 seconds is needed, change Location 22.

Example: 3 min. is desired for alarm.

3x60 = 180 sec., so the time delay desired is 180 seconds.

Divide the time delay desired by a number which will make the value entered in Location 04 below 102. In this case, we divided by 2. With a 2 in Location 22 and a 90 in Location 04, we have a 180 second delay (2 x 90 = 180).

Caution! Location 23 must be the same or larger than value in 22.

12. Follow the "Auto Cal Cycle Setup Procedure" on page 3-21 of the manual to set the automatic calibration cycle time.

13. Manual Zero/Span Check

Locate on the diagnostic board the zero/span switch and move it toward the zero position. Look at the display for the zero value and compare it to the value in Location 6. It should be ±2 counts of the Location 6 value. Move the bat switch toward the span position, and when the micro updates the display with the span value, compare it to Location 8. Span should be ±2 counts of Location 8.

Place bat switch in center position to shut the cycle off.

If the zero/span values match Locations 6 and 8, then the electronics are working properly, and the start-up is now completed.

14. Record any changes made in the micro under "Field Values" in the customer information list.

1100M OPACITY MONITOR

VERSION 13 FUNCTION LIST

The following locations have been assigned as user controls. The locations marked NOT USABLE are controlled by the processor and are not user controls. Those marked DISPLAY ONLY are used for trouble shooting.

Digi-Switch Location	Function
00	Selected display on control unit digital meter.- see Output/Display Code List on page 3-18.
01	EARLY WARNING limit. % opacity.
02	EARLY WARNING delay. event time in location 22.
03	ALARM limit. % opacity .
04	ALARM delay. event time in location 22.
05	AUTO CALIBRATION rate. hours.
06	CALIBRATION ZERO nominal value. % opacity.
07	PREVIOUS ZERO Measurement. % opacity.
08	CALIBRATION SPAN nominal value. % opacity.
09	PREVIOUS SPAN Measurement. % opacity.

Digi-Switch Location	Function
10	WINDOW Difference.
11	Display Only (Scale)
12	Display Only (Bias)
13	Display Only (Power supply check. 100 +/- 2 counts = all control unit supplies are good.)
14	Display Only (FAULT REASON code number.- see fault code list in Section 5)
15	PASSWORD 12 will unlock locations 16-99
16	ALARM/WARNING sense mode. (0=Fast Average, 1=Slow Average). (0).
17	DIGITAL PANEL DISPLAY - see list on page 3-20
18	PRIMARY CURRENT loop - see list on page 3-20
19	SECONDARY CURRENT loop - see list on page 3-20
22	*INSTANT AVERAGE time. Seconds.
23	*FAST AVERAGE time. Seconds.
24	*SLOW AVERAGE time. Minutes.
25	STACK L_X/L_T FACTOR, UNITS.
26	STACK L_X/L_T FACTOR, Tenths.
27	CALIBRATION DURATION. Minutes.
28	CALIBRATION CORRECTION RATE.
29	CALIBRATION AVERAGING time. Seconds.

*Instant average time must be the same or less than fast average time. Fast average time must be the same or less than slow average time.

Digi-Switch Location	Function
32	HIGH LAMP REFERENCE LIMIT.
33	LOW LAMP REFERENCE LIMIT.
35	DISPLAY ONLY lamp signal level.
36	WINDOW difference, LAMP reference, POWER SUPPLY, check repeat time in minutes.
37	WINDOW DIFFERENCE limit.
38	DIFFERENTIAL OFFSET
40	CURRENT WINDOW reference.
42	CURRENT WINDOW measurement.
43	LAMP DUTY CYCLE. (Do not change)
45	CLOCK SECONDS.
46	CLOCK MINUTES.
47	CLOCK HOURS.
48	UP/DOWN switch speed in 90ms increments.
99	SOFTWARE VERSION NUMBER

Output/Display Code List

The following codes are used to select the output function for the current loop outputs, remote meter, and the digital display.

1. SLOW AVERAGE OPACITY.
2. FAST AVERAGE OPACITY.
3. SLOW AVERAGE EXPANDED SCALE OPACITY.*
4. FAST AVERAGE EXPANDED SCALE OPACITY.*
5. SLOW AVERAGE OPTICAL DENSITY.
6. FAST AVERAGE OPTICAL DENSITY.
7. SLOW AVERAGE TRANSMITTANCE.
8. FAST AVERAGE TRANSMITTANCE.
9. SLOW AVERAGE OPACITY WITH CALIBRATION MARKS.
10. FAST AVERAGE OPACITY WITH CALIBRATION MARKS.
11. SLOW AVERAGE EXPANDED SCALE OPACITY WITH MARKS.*
12. FAST AVERAGE EXPANDED SCALE OPACITY WITH CALIBRATION MARKS.*
13. SLOW AVERAGE OPTICAL DENSITY WITH CALIBRATION MARKS.
14. FAST AVERAGE OPTICAL DENSITY WITH CALIBRATION MARKS.
15. SLOW AVERAGE TRANSMITTANCE WITH CALIBRATION MARKS.
16. FAST AVERAGE TRANSMITTANCE WITH CALIBRATION MARKS.

CALIBRATION MARKS DEFINITION

The CALIBRATION MARKS noted above are the measurements resulting from placing the instrument in 'SPAN' mode and in 'ZERO' mode. The marks are always displayed in the current output mode units (opacity, transmittance, etc.).

*Digital display will always be 0-100% or 0-1.02 O.D.

Automatic Calibration Cycle Set-Up

The micro control unit can automatically perform a zero span calibration check. The following locations control the automatic calibration Duration & Rate.

05 Auto Cal Rate
27 Calibration Duration
Scale

Location 05 is monitored on power up and again after each automatic zero and span check. This value can be updated in memory two ways:

1-Turn power off then on again.
2-The value updates when a calibration cycle is initiated.

The value in Location 05 is the number of incremental hours until the next cycle. A zero in Location 05 will prevent automatic calibration checks.

The amount of time spent in each mode is controlled by Location 27. An initialized value of 3 minutes in zero and again in span was chosen to give sufficient time on slow-moving strip chart recorder to leave a mark. In any event, this time should not be made less than 60 seconds.

IMPORTANT: THE FOLLOWING STEPS MUST BE DONE COMPLETELY AND IN SEQUENCE.

STEP 1

Determine the number of hours and minutes left in the current day until midnight on a 24 hour clock basis.

Example:

It is now 16:00 hours there are 8 hours left in this day until midnight.

STEP 2

Now change locations 46 (clock min.) and 47 (clock hrs.) to the number of hours and minutes left to midnight. The clock does not display actual time of day but will count down the Hrs., Min., until midnight.

Example:

In the example above in step 1 we found 8 hrs. were left in our day, therefore you would put 00 in location 46 and 08 in 47.

STEP 3

In Location 05, place a number equal to the number of hours until the first time you want the calibration to occur.

Example:

In our example above it is 16:00 hrs. and you want the auto. cal. to occur at 08:00 hrs the next day. We find there are 16 hrs. until 08:00 the next day, so you would enter 16 in location 05.

STEP 4

Turn the power switch of the control unit OFF than ON again.

STEP 5

Now determine the frequency at which you want the auto. cal. to occur after the first check.

Example:

We want the auto. cal. to occur every 4 hrs. after our first check at 08:00 hrs. You would then enter 04 in location 05.

A review of our example will show that the first check will occur at 08:00 hrs. the next day. The next checks will occur every 4 hours thereafter.

Calibration Correction

The rate of calibration correction during a calibration cycle is governed by Location 28 (calibration correction rate). If set to 3%, any error detected would be corrected at 3% per event time. Event time is equal to the fast average time Location 23 which is normally set at one second.

Location 28 should not normally be set higher than 5% correction rate.

If NO automatic calibration correction during Zero/Span check cycle is desired enter 00 in location 28.

EXPLANATION :

When the monitor is put into the zero calibration mode, Bias is automatically adjusted by the microprocessor to force the reading to the value of the Low neutral density filter (its value will be found in location 06). The adjusted number will be found in diagnostic Location 12 (bias correction).

When in the "span" mode, its gain is adjusted so that the monitor reads the value of the Hi neutral density filter (its value will be found in location 08). The adjusted number will be found in diagnostic Location 11 (scale correction).

Manual Initiation of Calibration Cycle

The control unit can manually perform zero and span calibration either of three ways:

1. Manually from the control unit zero/span cal switch, See Figure 1, Page 3-11.

2. By remote switch located on the remote meter (MEI) located in the reflector weather cover housing. See Drawing 100-6357, Section 2-8.

3. By remote switch or computer controlled relays, etc., connected to Terminals 8, 9, and 10, on the control unit. See Drawing 100-6357, Section 2.8. When in normal operation, Terminals 8 and 9 are high. When zero or span mode is desired, a remote switch will connect the appropriate terminal to digital ground Terminal 10. It will stay in that mode until terminal is un-grounded. When both are un-grounded and allowed to return to a logic high state, the unit will return to normal operation.

SLIDE CLEANING

AND

DIRTY WINDOW ALARM ADJUSTMENT

1. Clean both transmissometer and retro slides. The dirty window detector is on the left side of the transmissometer just forward of the slide assemble. Turn both wingnuts 1/4 turn and pry the plate free. Clean dirty window detector and replace with cell <u>facing toward you</u>.

2. Set Location 38 to 50.

3. Allow 6 minutes for control unit to update new levels.

4. a. Record the value in digi-switch Location 40.

   b. Record the value in digi-switch Location 42.

5. a. If location 40 is GREATER THAN 42, INCREASE the value in Location 38 by the amount found in Location 10.

   b. If Location 40 is LESS THAN 42, DECREASE the value in Location 38 by the value found in Location 10.

6. Select window alarm level by entering in Location 37 one count for approximately every 4% dirt accumulation limit desired.

7. Allow 6 minutes for control unit to update and clear alarm and turn off the dirty window L.E.D. on the front panel.

Stack Exit Correlation

Most regulations are written in terms of stack exit conditions so that the data taken can be compared on the same basis. As a result it is often necessary to correlate the readings of the opacity monitor to the stack exit conditions when the pathlength of the sensors is different than the stack outlet.

The control unit can be setup to automatically take the appropriate stack exit correlation factor into account. This feature enables the unit to output and display correlated Opacity, Optical Density and Transmittance.

In setting up the correlation ratio the following information is required:

L_x (round stack) = exit I. D. at the outlet

L_x (non-round stack) = $\sqrt{\dfrac{4 \text{ x area of the exit outlet}}{\pi}}$

L_t= stack I.D. at the sensor location

Use the formula below to find the correlation ratio:

$$\frac{L_x}{2 \text{ x } L_t}$$

Example:

L_x = 4 foot

L_t = 4 foot

$$\frac{4}{2 \text{ x } 4} = 0.5$$

Note: meters may be used as long as all dimensions are in meters.

Field Changes Of Stack Exit Correlation

If the sensor location or original information supplied was in correct and a change must be made in the field follow the procedure below.

1. Calculate the new correlation ratio (see formula on previous page). Let us assume it is .5 and we need to change it to 1.5 because we changed the sensor location.

2. To enter the new correlation ratio, (in this case 1.5) into the micro enter 01 in location 25 and 50 in location 26. The correlation is now changed.

When the correlation ratio is changed it is also changed for the zero and span check. This will cause the calibration points to change. We must now calculate what they will change to.

Let us assume your original correlation was .5 and the new ratio is 1.5 as above. Our zero mark is 10% and our span mark is 50%. To calculate what they will be use the following formulas:

$$T = 1 - \frac{\text{Opacity}}{100}$$

T_{x1} = Present mark in T (transmittance)

T_{x2} = New mark in T (transmittance)

M = Correlation ratio

M_1 = Present correlation ratio

M_2 = New ratio correlation

$$Tx_2 = (T_{x1})^{\frac{M2}{M1}}$$

EXAMPLE ON NEXT PAGE

Example:

Zero is 10% find T_{x1} : $T_{x1} = 1 - \frac{10}{100} = .9$

$M_1 = .5$

$M_2 = 1.5$

$$T_{x2} = (T_{x1})^{\frac{M2}{M1}} = .729$$

New zero mark in opacity = $100 \times (1 - T_{x2})$

New mark 27.1% = $100 \times (1 - .729)$

Repeat above for 50% and you should find the new mark to be 87.5%

In order for the automatic calibration adjustment to work you must:

a. Enter the new Zero value in location 06.

b. Enter the new Span value in location 08.

c. Perform a manual calibration cycle with 6 minutes in each position. Record the new value in the customers information sheet in the front of this manual.

SECTION 4

Maintenance

PREVENTIVE MAINTENANCE SCHEDULE

ITEM TO CHECK	FREQUENCY	PROCEDURE
Slides	As required	Clean with soft cloth, soap and water.
Dirty window assemble	at slide cleaning	Same as above.
Air filter screen (Located outside on bottom of the weather cover, inside rubber boot.)	at slide cleaning	Clean
Air filters	3 months	Clean or replace as necessary.
Air hoses	3 months	Replace as necessary.
Hose clamps	3 months	Inspect & tighten.
Mounting hardware	3 months	Check bolts for tightness.
Weather cover	3 months	Clean as required.
Beam alignment	3 months	Check and adjust as necessary.
Cables and connectors	6 months	Check,clean or replace as required.
Adapter flange	6 months	Examine for particle buildup. Push any buildup into stack to clear.
Protective inner window	6 months	Clean same as slides

CONTROL UNIT PREVENTIVE MAINTENANCE

Preventive maintenance consists of cleaning the instrument regularly and inspecting it occasionally for broken or damaged parts. Regular maintenance will improve the reliability of your instrument and prevent breakdowns.

Cleaning - Accumulations of dirt and dust on components act as an insulating blanket preventing efficient heat dissipation. Dust on circuit boards and wires can cause arcing and short circuits, resulting in damage to components or even instrument failure. Clean your instrument before this happens!

The cabinet provides protection from dust and dirt and should be in place during normal operation of the instrument.

Exterior - Dust the cabinet with a soft cloth. Dust the front panel controls with a small soft paint brush. Dirt clinging to the surface of the cabinet may be removed with a soft cloth dampened with a mild detergent and water solution. Avoid using abrasive cleaners. They will scratch the cabinet and front panel.

Interior - Dust in the interior of the instruments should be removed before it builds up enough to cause arcing and short circuits during periods of high humidity. Dust is best removed from the interior by dry, (approximately 9 $lb./in.^2$) low-pressure air. Dirt clinging to surfaces may be removed with a soft paint brush. Use a cotton-tipped applicator for cleaning in narrow spaces and on the circuit boards.

Visual Inspection - Inspect the interior occasionally for broken connections, improperly seated semiconductors, damaged or improperly installed circuit boards, heat damaged components, etc. If heat damaged components are found, care must be taken to find the cause of the excessive heat and measures must be taken to prevent recurrence of the damage.

Semiconductor Checks - Periodic checks of the semiconductor devices in this instrument are not recommended. The best check of semiconductor performance is actual operation in the instrument .

WEATHER COVER/BLOWER -PREVENTIVE MAINTENANCE

Periodically - check and clean the wire screen located on the outer, bottom side of the weather cover. This screen is located inside of the rubber boot. Inspect all hoses and wire connections inside the weather cover.

Air Filter - Empty collection container at the bottom of the air filter. Remove it by turning key to loosen the band holding it in place. Pull the container down and remove the rubber insert to empty any heavy particles. Before replacing unscrew the wing nut holding the filter cartridge in place. It should be exposed to view where you took the container off. Remove and inspect, clean or replace filter cartridge as necessary.

Protective slides - Clean window slides when indicated by the control unit window alarm L.E.D.

Caution: Do not clean the retroreflector surface(located inside sealed cover behind the iris) on a routine basis . This should remain clean. Frequent cleaning can scratch the surface and damage the reflector beyond repair.

Calibration Lamp Replacement

Remove only the transmissometer to a clean work area. It is not necessary to remove blower weather cover. It is advisable on positive pressure stacks to place a plate to stop any gasses from entering the weather covers after the transmissometer is removed.

1. Remove the side and back cover of the sensor by turning the 1/4 turn screws. It may be necessary to pry them of as the gasket may stick to the metal, be careful not to damage the gasket.

2. Looking from the back, you will see the two calibration lamp sockets just above the main lamp socket. Remove the four 4-40 slotted screws to the left and right of these sockets.

3. Pry off the plate the sockets are on.

4. Remove the lamps by unscrewing the knurled sleeve adapter counterclockwise. The lamps will come out with the adapter. Push the lamp out from the adapter and replace with the new lamps. Make sure the number on the old lamps match the new ones.

5. Screw the lamps into the sockets, replace all the holding screws and covers.

6. Reinstall the transmissometer.

7. Initiate a Zero calibration check for 6 minute then a Span check for 6 minutes.

Main Lamp Replacement Procedure

1. Remove the two cables going to the transmissometer by unscrewing the connectors.

2. Remove the transmissometer side cover by turning the 1/4 turn screws counterclockwise.

3. Locate the main lamp in the lower right hand side of the enclosure. Push up on the lamp socket and turn the lamp counterclockwise 1/4 of a turn and remove.

4. Insert the new lamp with the filament facing toward the first lens.

5. This adjustment will have to move the filament image vertically up or down. It will be necessary to bend the lamp socket's bracket to do this. DO NOT LOOSEN THE HEX HEAD SCREWS. (Also see 5.10)

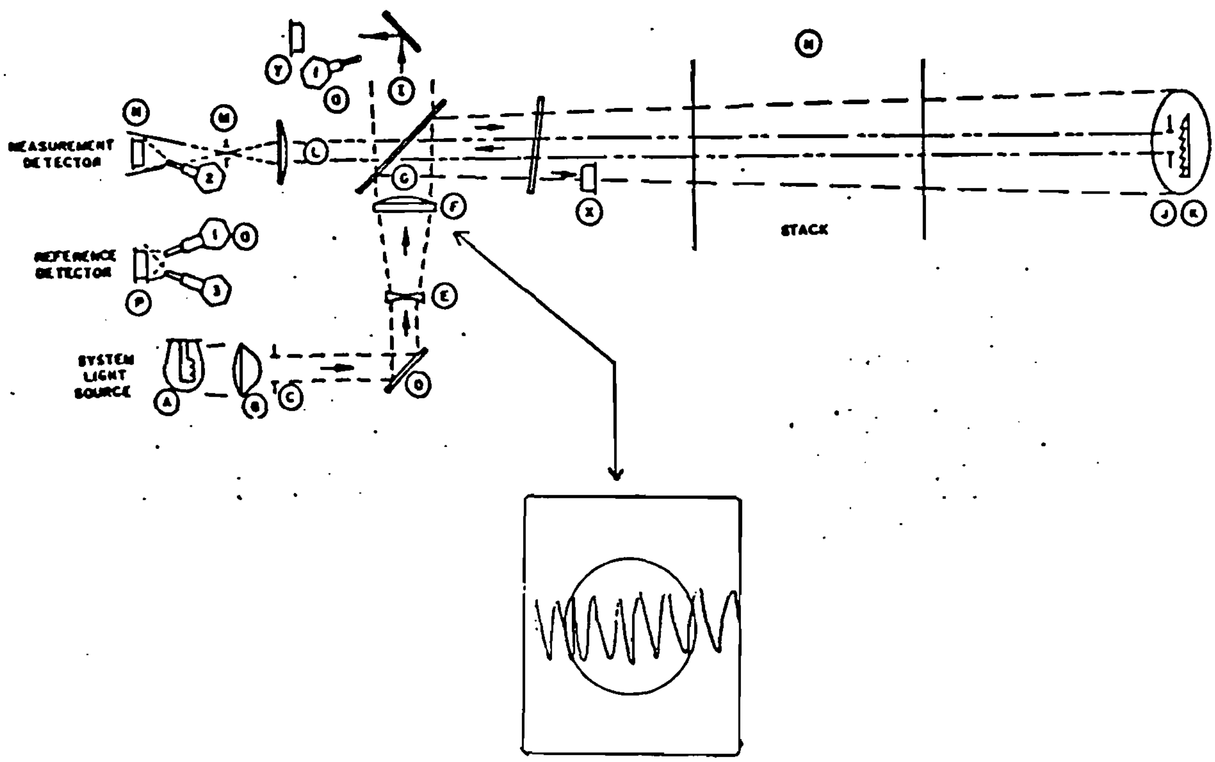


Fig. 1

List of Spare Boards and Parts (optional)

Model 1100M Control Unit

123-5802	Control Unit Test Cables
100-6277	Relay Board
100-6320	Power Supply
100-6328	Input Board
100-6329	Micro Board
100-6330	Diagnostics Board
100-6331	4-20 Output Board
110-5802	Test Cable Set (10 ft.)
100-6332	Digital Display Driver
100-6333	L.E.D. Indicator Board
8-463A	115/220 V 5/1 Amp Relay
15-0072	Fuse 2 amp

TRANSMISSOMETER

100-6002	Detector Board
100-5926-5	Dirty Window Detector
6-789	Main Lamp
6-1089	Calibration Lamps
110-5022	Protective Slides (2)
100-6374	Stack Mounted Power Supply

RETRORELECTOR

6-0609	Target Lamp

Blower Weather Cover

123-5620	Spare Blower
123-5633	Cartridge Filter Replacement Element for Blower Weather Covers
10-1538	Air Flow Switch
27-1529	6" 150 lbs Gasket
30-1501	2" Flexhaust Air Hose
30-1500	1-1/2" Flexhaust Air Hose
30-1485	2" S.S. Hose Clamp
30-1579	1-1/2" S.S. Hose Clamp
30-1482	2" X 90 Degree Elbow
30-1483	2 X 1-1/2" Reducer
30-1484	2 1/4 X 2 Reducer
20-3001-3	Silicon Thermo-Gasket

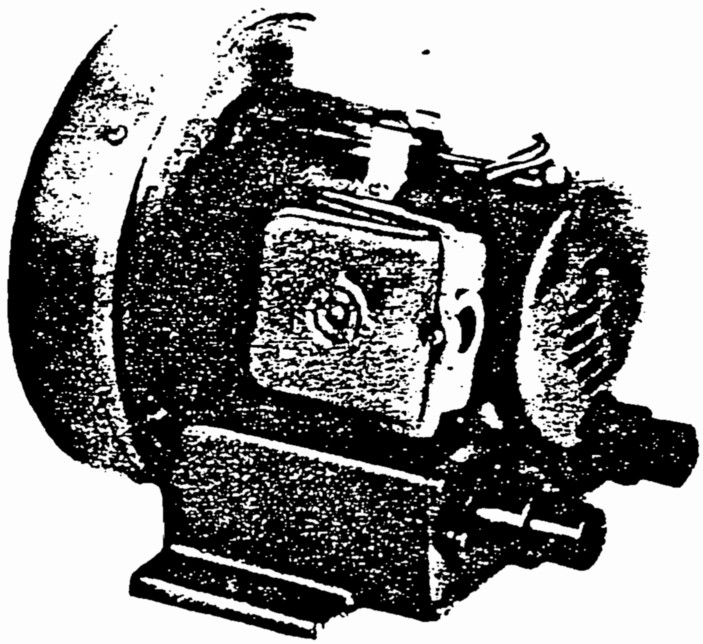
MISCELLANEOUS

100-6571-2	On Line Test Reflector with Neutral Density Filters (Low, Med, Hi) and Carrying Case
100-6371-2	Neutral Density Filter Kit (Low, Med, Hi)
123-5540	Cable - 9 twisted shielded pair of 18-gauge wire/Ft.

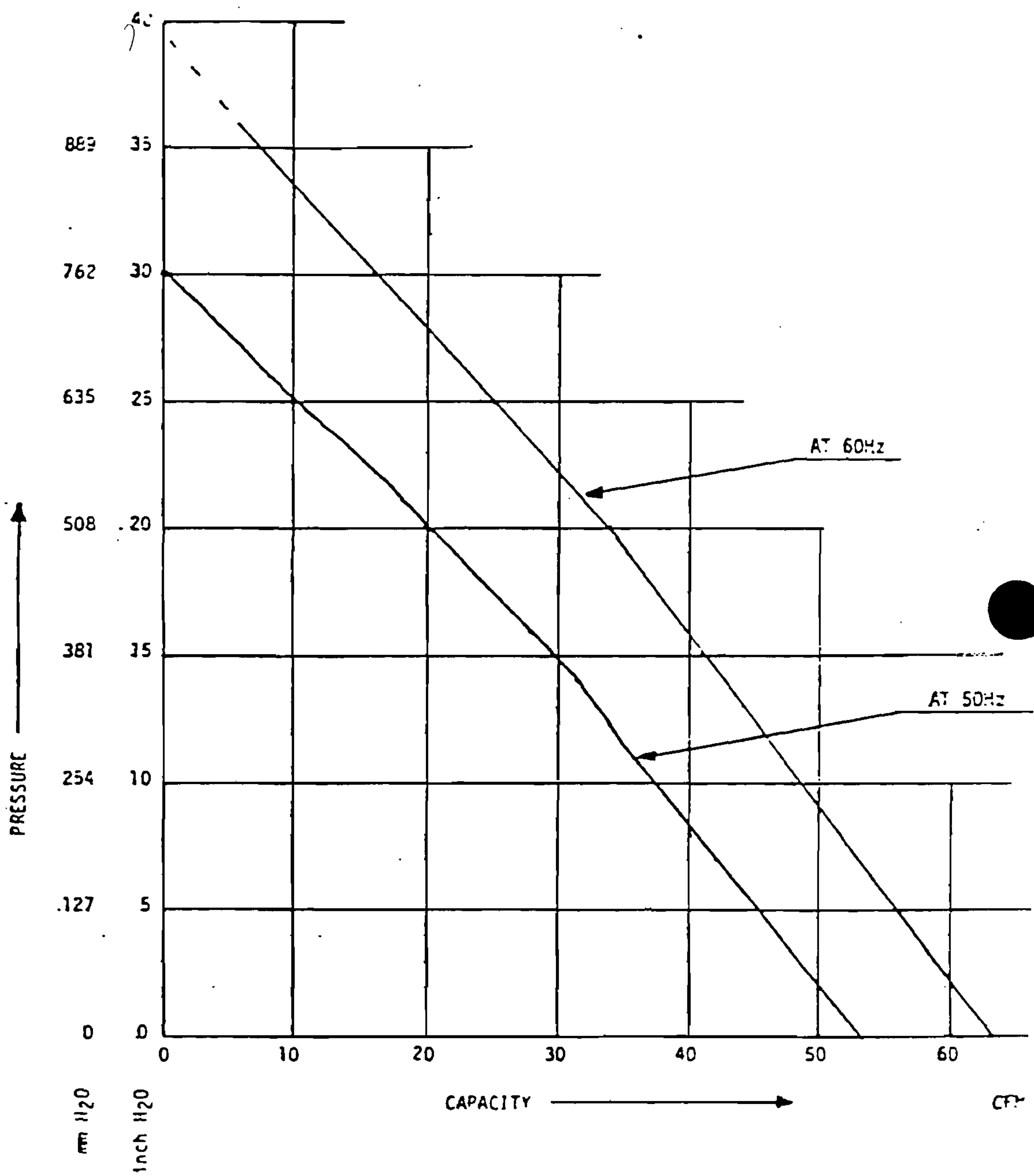
Instruction Manual

Blower Instruction Manual

Operating and Instruction Manual



Model NO.: VB003S



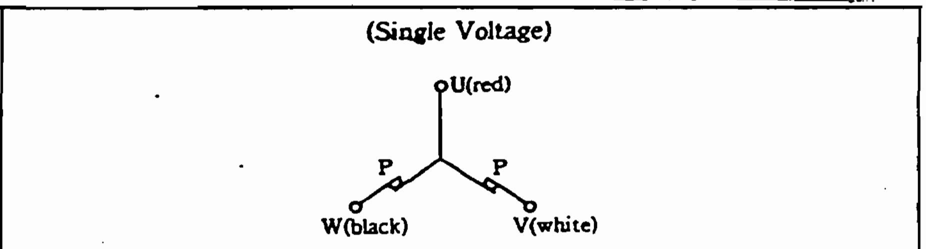
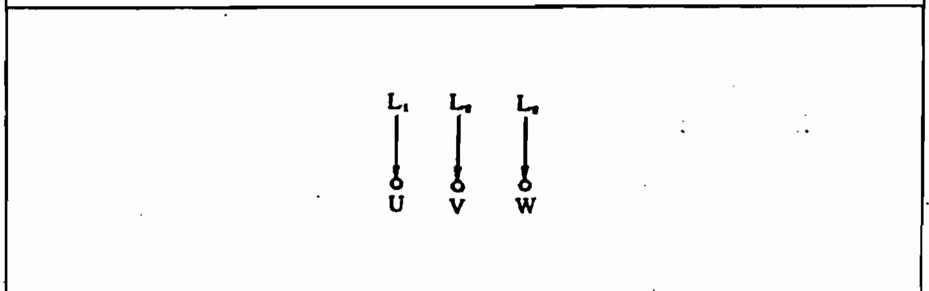
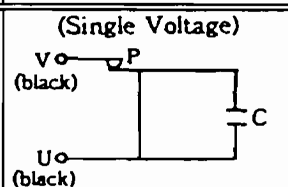
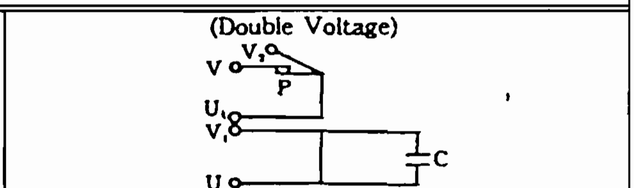
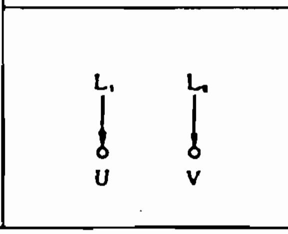
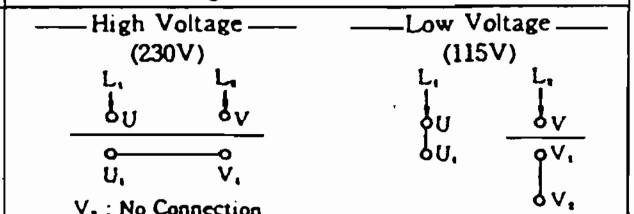
AT 60Hz
AT 50Hz
PRESSURE
CAPACITY
mm H2O
inch H2O
889
762
635
508
381
254
.127
0
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60

Wiring

For wiring, use wires, switches, etc. in accordance with the data shown in Table 1 in compliance with National Electric Code and applicable local codes.

Table 1 Motor Data

Model No.	VB003S-B	
Phase	1	
Hertz	60	
Output(W)	250	
Voltage(V)	115	230
Current(A)	3.4	1.7
Capacitor(Mfd.)	30	
Starting Time(sec.)	6.5~8.5	
Locked Rotor Current(A)	10	6.5

Motor Connection	3 phase Motor		
			
	1 phase Motor		
			

Note.
1. Data will be subject to change without notice.
2. P indicates Thermal Protector.
3. C indicates Capacitor.

Temperature Rise

A NEMA class B insulation system is used for motor, maximum winding temperature is 130℃. If Thermal Protector activates or temperature rise of motor is higher than usual, the following causes should be considered :

(1) Phase unbalance (must be within that ±5%)

(2) Voltage variation (must be within than ±10% of rated)

(3) Blower is operated in an environment of solid dust and impeller performance impaired by contamination of particles.

(4) Operating at more than maximum operating pressure.

(5) Operating at low air volume (close to zero volume).

(6) Single phase operation (3 Phase Motor).

Sealed Bearings

Although sealed ball bearings with high-quality grease are used for long term operation without regreasing, check bearings periodically and if necessary make appropriate Bearing changes. (according to Fig. 6)

■ Disassembly and Reassembly

1. Special Note (See Warranty Terms)

The following precautions should be taken when disassembling or reassembling the Blower :

(1) Keep all parts clean.

(2) Do not over tighten bolts, nuts and screws. (torque limits are in Table 2)

(3) Do not damage stator windings.

Table 2

UNIT: lb·in (kg·cm)

Screw size (Bolt, Nut)	M3	M4	M5	M6	M8
Torgue limit	7.8 (9)	17 (20)	31 (36)	66.5 (77)	156 (180)

2. Procedure of Disassembly(Reassembly is in reverse order)

Special note : Disassembly of motor section cause a drop in the accuracy of the narrow gap between the impeller and the casing. When disassembling motor section, advise contacting Factory.

(1) Take side cover off.

(2) Unfasten lock washer (VB003S-B, VB003) and remove impeller.

(3) Remove casing from bracket.

(4) Unfasten screws on bracket.

(5) Remove end cover.

(6) Remove outer fan by unfastening the screw.

(7) Remove end bracket from housing.

(8) Remove shaft, ball bearing, bearing cover and rotor core.

(9) Remove bracket from housing.

3. Removal or Installation of Ball Bearings

Remove or install ball bearings according to Fig. 6 with the following precautions:

(1) Press vertically to prevent damage of ball bearings or shaft.

(2) Press the entire side surface of the bearings or inner race only.

The outer race should not be pressed by itself.

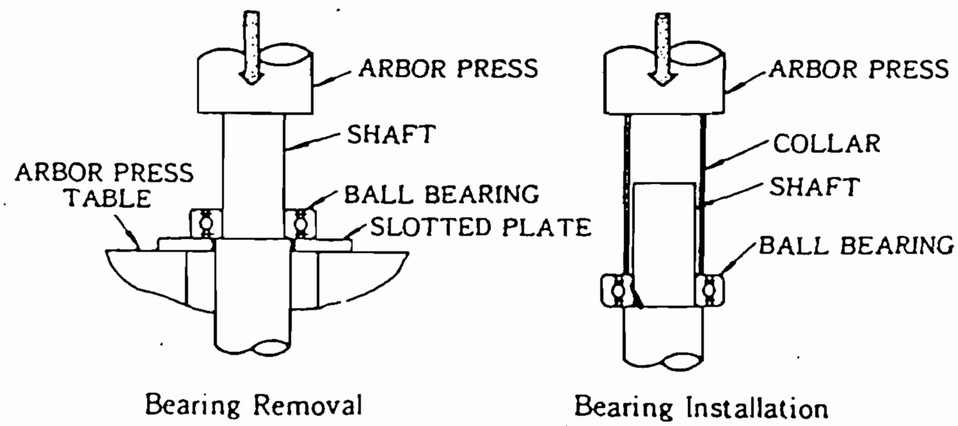


Fig. 6

3. Impeller Disassembly

Remove the Impeller by pulling it in the direction of the moter shaft. If the fit is tight, use a puller as shown in Fig.7.

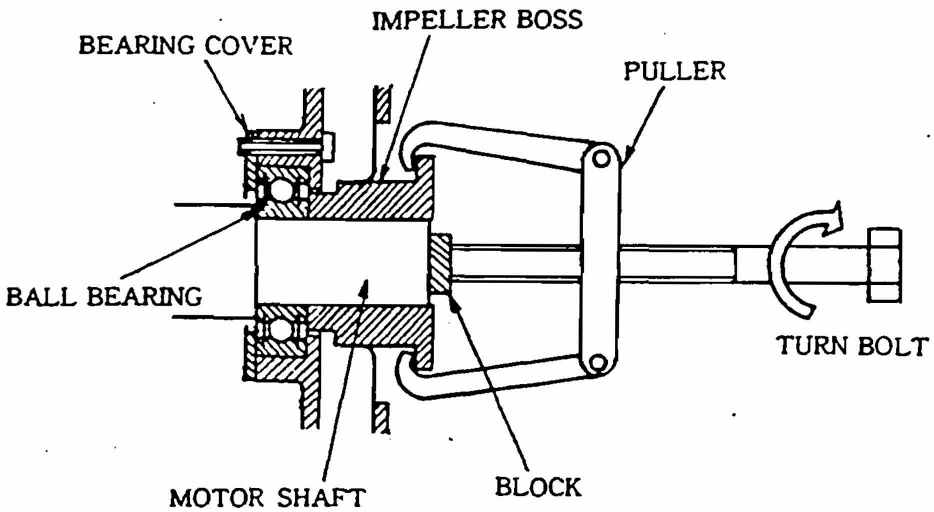


Fig.7

4. Impeller Reassembly

When reassembling, check the narrow gap between the Impeller and the Casing with a Gap Gauge.

The gap between the Impeller and the Casing is 0.3mm~0.6mm(0.012~0.024 inch)

If the gap is abnormally, advise contacting factory.

Trouble Shooting

When Blower Does Not Turn

Humming Sound

1. Single phase operation (3 Phase Motor) → Check connection
2. One side of Stator Winding open → Contact factory
3. Capacitor open → Change Capacitor
4. Bearings defective → Change Bearings
5. Impeller jammed by foreign material → Clean Impeller
6. Impeller jammed against Casing or side Cover → Contact factory
7. Rubbing of Rotor Core and Stator Core → Contact factory

No Sound

1. Power line broken → Connect
2. Both of Stator Winding open (1 phase Motor) → Contact factory
3. Two phases of Stator Winding open (3 phase Motor) → Contact factory
4. Faulty Switch connection → Change Switch
5. Fuse blown → Change Fuse

When Blower Turns

Blown Fuse

1. Fuse capacity insufficient → Change Fuse Capacity
2. Terminals shorted → Improve Terminal's insulation and check connection

Overheated or Protector is Activated

1. Power source unbalanced or voltage drop → Check voltage
2. Operating in single phase condition (3 Phase Motor) → Check connection
3. Excessive friction due to defective Bearings → Change Bearings
4. Impeller contaminated by foreign material → Clean Impeller
5. Impeller rubbing against Casing or Side Cover → Contact factory
6. Rubbing of Rotor Core and Stator Core → Contact factory

Abnormal Sound

1. Impeller rubbing against Casing or Side Cover → Contact factory
2. Impeller rubbed by foreign material → Clean Impeller
3. Bearings defective → Change Bearings (See warranty terms.)

Abnormal Vibration

1. Impeller contaminated by foreign material → Clean Impeller
2. Impeller modified by foreign damage → Contact factory
3. Impeller vibrates abnormally → Tighten Nuts and Bolts

SPARE PARTS LIST-VORTEX BLOWER

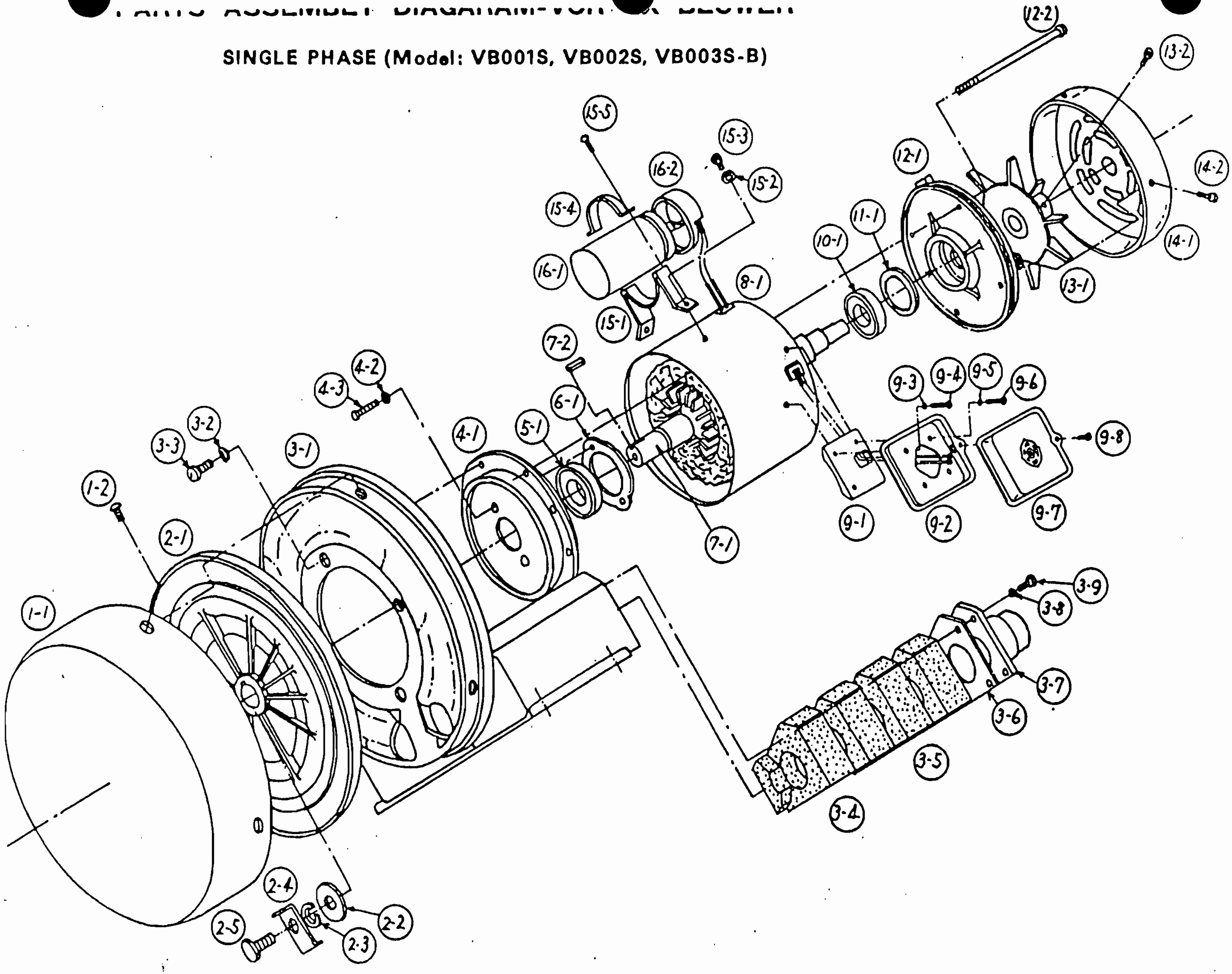
Model: VB001S, VB002S, VB003S-B

Typical example : Side Cover for VB002S blower · : Part № 018109

ITEM №	NAME	VB001S	VB002S	VB003S-B	ITEM №	NAME	VB001S	VB002S	VB003S-B
1-1	Side Cover	018169	018109	018151	9-1	T.M Base	——	018131	018131
1-2	Screw	018110	018110	018110	9-2	T.M Box	018132	018132	018132
2-1	Impeller	018170	018111	018101	9-3	Washer	018133	018133	018133
2-2	Washer	018171	018112	018152	9-4	Earth Screw	018184	018134	018134
2-3	Spring Washer	018113	018113	018113	9-5	Washer	018135	018135	018135
2-4	Lock Washer	——	——	018114	9-6	Screw	018110	018136	018136
2-5	Bolt	018172	018115	018153	9-7	T.M Cover	018137	018137	018137
3-1	Casing	018173	018116	018154	9-8	Screw	018138	018138	018138
3-2	Spring Washer	018117	018117	018117	10-1	Ball Bearing	018180	018139	018139
3-3	Screw	018118	018118	018118	11-1	Spring	018185	018140	018140
3-4	Absorber	018174	018119	018155	12-1	End Bracket	018186	018141	018162
3-5	Absorber	018175	018120	018156	12-2	Screw	018187	018142	018163
3-6	Packing	018176	018121	018157	13-1	Outer Fan	018188	018143	018164
3-7	Bracket	018177	018122	018158	13-2	Screw	018189	018144	018144
3-8	Spring Washer	018123	018123	018123	14-1	End Cover	018190	018145	018145
3-9	Screw	018110	018124	018124	14-2	Screw	018191	018138	018138
4-1	Bracket	018178	018125	018125	15-1	Capacitor Base	——	018146	018146
4-2	Spring Washer	018123	018123	018123	15-2	Washer	——	018135	018135
4-3	Screw	018179	018126	018126	15-3	Screw	018138	018138	018138
5-1	Ball Bearing	018180	018127	018127	15-4	Capacitor Holder	018192	018147	018147
6-1	Bearing Cover	018181	018128	018128	15-5	Screw	018193	018148	018148
7-1	Shaft and Rotor Assy.	018182	018129	018159	16-1	Capacitor	018194	018149	018107
					16-2	Capacitor Cap	018150	018150	018150
7-2	Key	——	——	018160					
8-1	Housing, Stator and Protector Assy.	018183	018130	018161					

PARTS ASSEMBLY DIAGARAM-VORTEX BLOWER

SINGLE PHASE (Model: VB001S, VB002S, VB003S-B)



SECTION 5

Troubleshooting

PROBLEM LIST

We have listed major problem categories below and the page number in this section you should turn to for assistance in troubleshooting the system.

TROUBLESHOOTING

The following information is provided to help you keep your 1100M in good operating condition. We recommend that service be done by qualified service personnel only.

If you perform preventive maintenance on a regular basis, you should correct most problems before your instrument breaks down. Occasionally, you may have to troubleshoot. In addition to the following information, you may find the Circuit Diagrams useful in Sections 6,7 and 8.

Troubleshooting Aids:

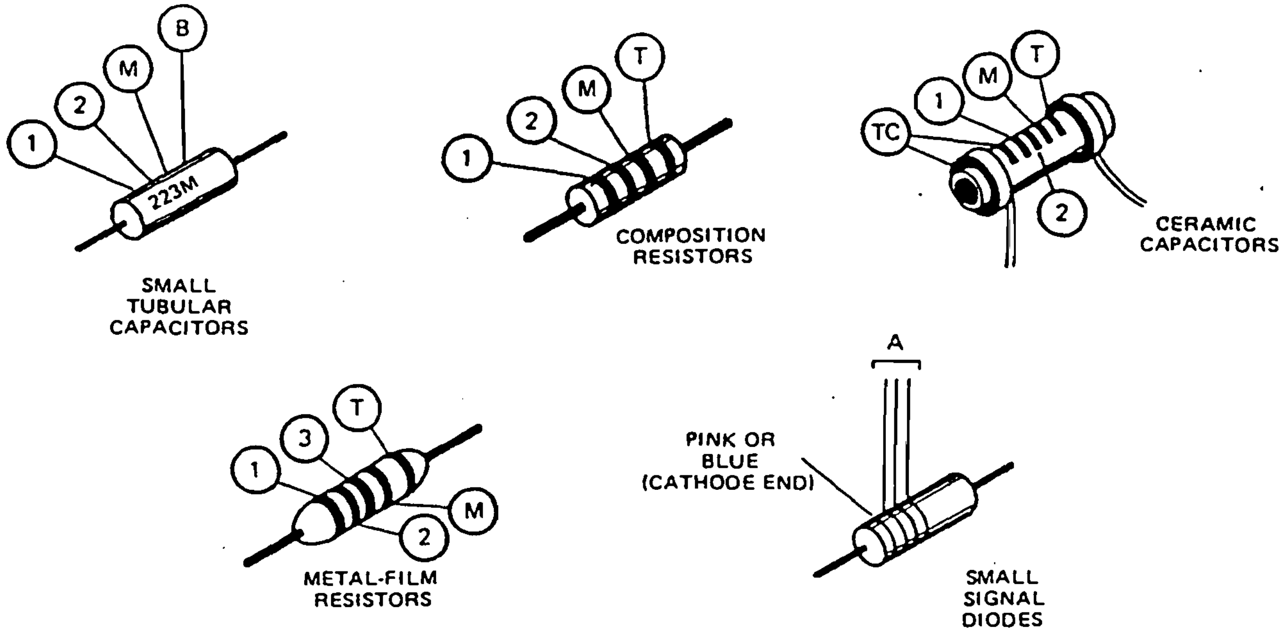
Diagrams - Complete circuit diagrams are located in Section 8. The component in the instrument are shown on the diagrams.

Color Codes - The resistors used in this instrument are either brown composition or precision metal-film resistors. The resistors are color-coded with the EIA color-code. (Some metal-film resistors may have the value printed on the body.) Refer to Fig. 5-2. For the values of the thick film resistors, refer to the Parts List.

The Capacitance values of common disc and some small electrolytic capacitors are marked on the side of the component body. The white ceramic capacitors are color-coded, using a modified EIA code. (See Fig. 5-2).

The cathode end of each glass-encased diode is indicated by a stripe, a series of stripes, or a dot.

Semiconductor Lead Configuration - Fig. 5-3 shows the lead configuration of the semiconductor devices used in this instrument.



(A) COLORS IDENTIFY SIGNIFICANT DIGITS IN TEKTRONIX PART NUMBER (E.G. BROWN, GRAY, GREEN STRIPES INDICATE PART NUMBER 152-0185-00)

(B) TOLERANCE: F=±1%, J=5%, K=10%, M=20%

(1) (2) and (3) 1ST, 2ND, AND 3RD SIGNIFICANT FIGS.

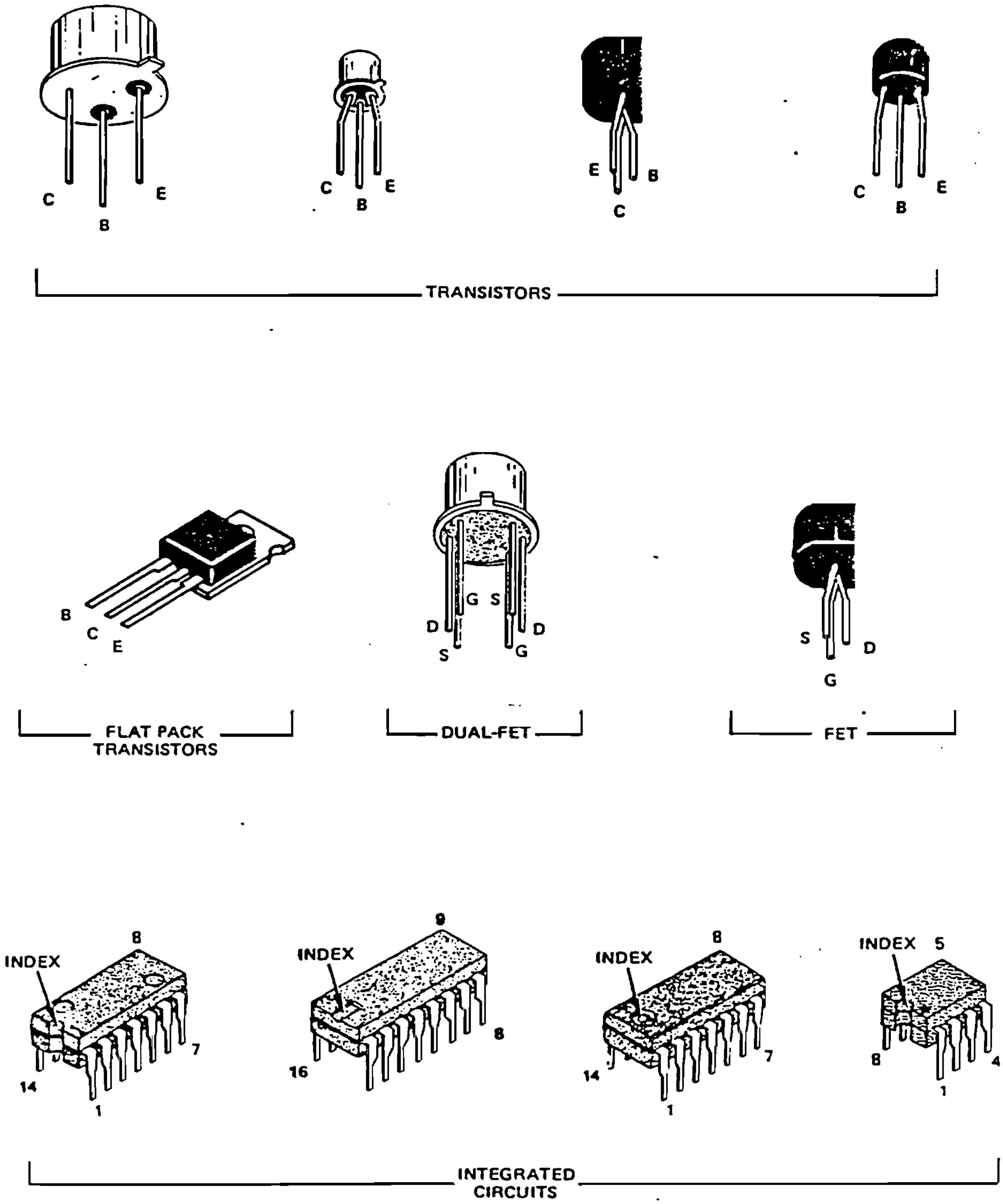
(M) MULTIPLIER (T) TOLERANCE:

(TC) TEMPERATURE COEFFICIENT.

(T) AND/OR (TC) COLOR CODE MAY NOT BE PRESENT ON SOME CAPACITORS:

COLOR	SIGNIFICANT FIGURES	RESISTORS (Ω)		CAPACITORS (pF)		
		MULTIPLIER	TOLERANCE	MULTIPLIER	TOLERANCE	
					over 10 pF	under 10 pF
BLACK	0	1	---	1	±20%	±2 pF
BROWN	1	10	±1%	10	±1%	±0.1 pF
RED	2	10^2 or 100	±2%	10^2 or 100	±2%	---
ORANGE	3	10^3 or 1 K	±3%	10^3 or 1000	±3%	---
YELLOW	4	10^4 or 10 K	±4%	10^4 or 10,000	+100% −9%	---
GREEN	5	10^5 or 100 K	±½%	10^5 or 100,000	±5%	±0.5 pF
BLUE	6	10^6 or 1 M	±¼%	10^6 or 1,000,000	---	---
VIOLET	7	---	±1/10%	---	---	---
GRAY	8	---	---	10^{-2} or 0.01	+80% −20%	±0.25 pF
WHITE	9	---	---	10^{-1} or 0.1	±10%	±1 pF
GOLD	-	10^{-1} or 0.1	±5%	---	---	---
SILVER	-	10^{-2} or 0.01	±10%	---	---	---
NONE	-	---	±20%	---	±10%	±1 pF

FIGURE 5-2


C
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E
C
B
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E
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B
E
TRANSISTORS
B
C
E
FLAT PACK
TRANSISTORS
G S
D
D
S
G
DUAL-FET
S
D
G
FET
INDEX
8
7
14
1
INDEX
9
8
16
INDEX
8
7
14
1
INDEX 5
8
4
1
INTEGRATED
CIRCUITS

FIGURE 5-3

OPACITY TROUBLESHOOTING GUIDE

The micro chassis has a very strong self-diagnostic test program. With its ability to monitor many system parameters, most indications of problems and clues to causes will start with the Diagnostic Center. It is highly recommended you read Control Unit Explanations before proceeding.

Diagnostic Center Operator Controls (Control Unit):

To access the operator controls unlock the two front panel knobs in the opposite direction shown by the arrows. While holding knobs pull forward and the chassis will slide out. Pull out only far enough to reach controls or power switch. Caution: chassis does not have stops, pulling to far will cause it to fall out of the cabinet.

YOU MUST enter the "password" number 12 in location 15 to change any values in locations 16 and up. (See control unit explanations in section 3.)

Symptom

Fault diagnostic light on:

Turn digi-switch to location 14 for display of fault reason code number. The numbers will be the addition of the code numbers if you have multiple faults.

For example, if you have a 1 displayed the Retro air flow is low. Now if a 5 were displayed checking the fault code list on the cover (or from the code list on page 3-16) the only possible codes adding to equal 5 are 1&4. Your multiple problem is, Retro air flow and Lamp intensity out of tolerance.

Code 1 Retro air flow switch circuit open.

Check for loose or broken wires on terminals 6 & 20 of the control unit.

Short Ter 6 & 20, if code goes to 00 and fault lamp goes out problem is not in the Control unit continue on to the next page.

If problem still exists change or repair in put board 100-6382.

Code 1 Retro air flow switch circuit open. (continued)

Check connections at the stack location per drawing 100-6357.

Check the blower is running.

Check purge system, screen, filter and plenum for blockage.

Check the switch with an OHM meter to insure it is closed, if all air flow appears good follow switch adjustment as outlined in the start-up procedure. If it still fails to close replace the switch.

Code 2 Transmissometer air flow switch circuit open.

Check terminals 7 & 20 of control unit.

Same as above but for transmissometer.

Code 3 Both weather cover air flow circuits open.

Code 4 Main lamp intensity out of tolerance.

Check locations 32 & 33 are at the field values marked in the Customer Information Sheet provided.

If the value in location 35 is 20 counts below the value in location 33, but not Zero the lamp is dim. Check that location 43 is at the value selected by the factory (see customer information sheet) if not enter the correct value and wait 6 minutes to see if fault lamp goes out.

If this is a start-up or any work to wiring has been done and lamp is still low check terminals 16 and 17 wires are not reversed any were from the control unit to transmissometer cable connectors.(see Drawing 100-6357)

If the value in location 35 is over or under the low/hi lamp limits by a few counts it is not a problem at this time. Increase or decrease as needed the value in locations 32 or 33 by 5 counts and wait 6 min. When the micro updates the fault lamp will go out.

LOW LAMP INTENSITY DOES NOT EFFECT OPACITY READINGS.

Code 4   Main lamp intensity out of tolerance.(continued)

If location 35 is 00 main lamp is off check wiring and cables.

Check the target switch was not left in the ON position.
Check the target switch.

Check for power to the weather covers.

Check the stack power supplies by pushing the screen covering the test point and measuring them. If any are missing check the fuses on the power supply. If fuses are blown repair or replace the power supply.

Check the bulb and replace only if the glass is black or filament is open. If the filament is dim it is not the bulb, do not replace the bulb.

Code 8   Ram refresh required.

Do ram refresh procedure.

Check the battery. Test voltage on the Micro Board 100-6329 if it is below 2.8 volts replace it.

Code 64   Software error do ram refresh procedure.

Code 128 Software error do ram refresh procedure.

Display reads "HELP'   Software error do ram refresh procedure.

Dirty Window Alarm is on:

Clean slides and perform Dirty window alarm adjustment in section 3

If still not out after above check location 42 for zero. If zero check all associated wiring. Check the measurement cell by measuring resistance. Zero or very low resistance when light is on detector and several megohms with no light, replace if defective.

Check location 40 for zero. If zero check all associated wiring. Check the reference cell by measuring resistance. Zero or very low resistance when light is on detector and several megohms with no light, replace if defective.

No alarm contact closures with hi opacity:

Check locations 01,02,03,and 04 are correct values and location 22 value is 01.

Check relays on 100-6277 output relay board replace if defective. If relays are good check wiring is correct. Repair or replace 100-6277 relay board.

No output or wrong current outputs:

Check all associated wiring and external equipment are operating correctly.

Check locations 17 & 18 are correct values from Output/Display code list section 3.

Check customer information that correct current output was supplied.

Repair or replace 100-6331 output board.

Cannot change values in locations:

If locations 00-15 can be changed but 16 and up can not enter password number "12" in location 15.

If locations 00-15 can not be changed check increase/decrease switch.

If switch is in good repair or replace diagnostics board.

Calibration marks are off:

Check values are correct in locations 25 & 26

Check locations 06 & 07 are correct values as in the customer information sheet. Enter 03 in location 28 and manually perform a zero then a span cycle leaving in each mode for minimum of 6 minutes.

Main lamp on all the time:

If the bulb is not modulating (flickering) and is very bright check that the "Lamp Steady" switch is off, bad control wiring, or bad stack power supply.

Main lamp is out:

Check modulation signal is at terminal 16 on the control unit (take the wire off to assure it is not shorted). If no modulation at the control unit repair or replace the input board 100-6328.

If good at the control unit, check modulation signal is at terminal 2 and P3 pin A in the weather cover. If signal is good into the power supply check target lamp switch is off.

Check stack power supply for proper voltages, and that modulation signal is on P1 pins A and B. Replace power supply if any voltages or signals are not present.

Check the main bulb with an ohm meter if all voltages are good. Replace if the filament shows open.

Main lamp is dim:

Check that location 43 is at the value selected by the factory (see customer information sheet) if not enter the correct value.

If this is a start-up or any work to wiring has been done and lamp is dim check terminals 16 and 17 wires are not reversed any were from the control unit to transmissometer cable connectors. (See Drawing 100-6357)

Fault Code 4 after the main lamp has been changed and location 35 value is below ref. limit in location 33.:

Lamp bracket has been bent when new bulb was installed. Line up the filament image in the center of the focusing lens (F) by returning lamp bracket (A) back to original position, see figure 1. It will be necessary to look up from under the lens bracket to see light coming from the main bulb. When corrected wait 6 minutes for fault to go away and value in location 35 will rise above location 33 value.

If dirty window light is on after above is corrected do the window adjustment. This will clear any misalignment of the beam on the window reference detector.

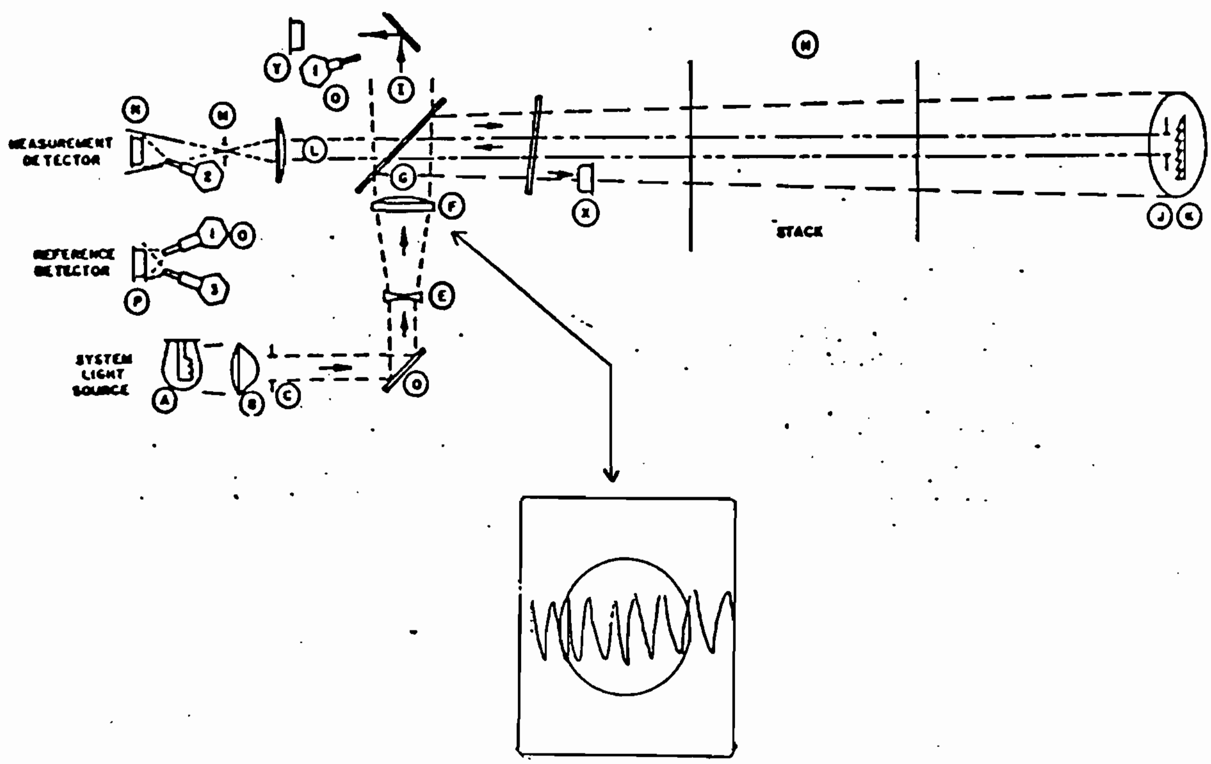


FIGURE 1

No lamp modulation:

Check terminal 16 of the control unit for a square wave pk to pk 0 to 4 volts. If no square wave check cable is not shorted, if wire is good replace or repair input board 100-6328.

If square wave is present check wiring to stack power supply.

Check stack power supply voltages and square wave across P-1 pins A & B. If signal is good in but not out of power supply replace power supply.

Calibration Repeat Time is off:

This will occur after a power failure because the clock will hold at the time power is removed and will stop counting down until power is resumed.

IMPORTANT: THE FOLLOWING STEPS MUST BE DONE COMPLETELY AND IN SEQUENCE.

STEP 1

Determine the number of hours and minutes left in the current day until midnight on a 24 hour clock basis.

Example:

It is now 16:00 hours there are 8 hours left in this day until midnight.

STEP 2

Now change locations 46 (clock min.) and 47 (clock hrs.) to the number of hours and minutes left to midnight. The clock does not display actual time of day but will count down the Hrs., Min., until midnight.

Example:

In the example above in step 1 we found 8 hrs. were left in our day, therefore you would put 00 in location 46 and 08 in 47.

STEP 3

In Location 05, place a number equal to the number of hours until the first time you want the calibration to occur.

Example:

In our example above it is 16:00 hrs. and you want the auto. cal. to occur at 08:00 hrs the next day. We find there are 16 hrs. until 08:00 the next day, so you would enter 16 in location 05.

STEP 4

Turn the power switch of the control unit OFF than ON again.

STEP 5

Now determine the frequency at which you want the auto. cal. to occur after the first check.

Example:

We want the auto. cal. to occur every 4 hrs. after our first check at 08:00 hrs. You would then enter 04 in location 05.

A review of our example will show that the first check will occur at 08:00 hrs. the next day. The next checks will occur every 4 hours thereafter.

Unit never goes into auto cal:

If location 05 is 00, it will not go into auto cal. You must enter appropriate repeat hours.

Unit canot be manually made to go into a zero, span, or both check mode:

Short to ground (10) terminals 8 or 9 on rear panel of control unit. If unit cycle S2 on diagnostic board 100-6330 is open, replace switch. If unit does not cycle, replace 100-6330 diagnostics board. If 100-6330 is good, check U7 on 100-6328 input board.

Unit stays in zero/span calibration mode:

Check control lines are not grounded on the control unit by disconnecting terminals 8 and 9 (see 100-6357). If the unit returns to normal, find which line is shorted to ground. If condition remains, check S2 on diagnostics board; replace board 100-6330. Check remote meter switch in the retro weather cover is in the center position and it is not shorted causing a grounded control line.

HIGH OPACITY

1.) Before any troubleshooting begins, please verify that a problem does exist between the stack's outlet opacity and the opacity monitor reading by having a certified smoke reader correlate the opacity monitor's reading to what he observes exiting the stack. If he verifies a high opacity problem with the unit, follow this troubleshooting guide.

Problems with the opacity monitor are grouped into two categories: A.) Electrical, and; B.) Mechanical.

2.) Electrical

NOTE: Main lamp will NOT affect opacity unless it is completely out. DO NOT replace it for high opacity problems.

A.) Initiate a manual zero cycle from the diagnostics board. Compare the D.P.M. reading to those in both the Customer Information section of the manual and Micro locations 6.

Initiate a manual span cycle from the diagnostics board. Compare the D.P.M. reading to those in both the Customer Information section of the manual and Micro locations 8.

B.) If the values are the same ±2 counts, the problem is NOT electrical. Follow the mechanical troubleshooting guide on Page 5-16.

C.) If the values are NOT equal, perform the following checks:

1. Compare the factory selected values in the Customer Information section to those presently in the micro. Locations 6, 8, 11, 12, 25, 26 and 28 are especially critical. Change them to match the factory or field selected values.

2. If locations 11 and 12 have changed drastically from factory selected values, remove auto correction by changing Location 28 from 03 to 00. Make 11 and 12 each 50, and then initiate a manual zero/span check. If calibration readings are now correct, enter 03 in location 28. If normal operation is still high, go to Page 5-16, Mechanical section.

If calibration marks do not return to original values , a bad amplifier, EPA bulb, fiber optic, zener diode, stack supply, or wiring are at fault continue on.

3. Put the unit into a zero cycle, look at terminal 2 on rear panel of the control unit with an oscilloscope. There should be 1v pk-pk sawtooth reference signal. Terminal 2 (measurement signal) should be the same sawtooth but about .8v pk-pk.

4. If either or both are missing check wiring from control unit to transmissometer, see drawing 100-6357.

5. Check + and -5v supplies on stack mounted power supply (100-6366). If either one or both are not within 200 mv, repair or replace the power supply.

6. Check measurement and reference signals at the test jacks located under the perforated screen on the stack power supply with a scope. They should measure 50mv pk-pk with the unit in the zero cycle (NOTE: A zero can manually be done by jumping TB1/10 to TB2/8 on light source side.). If there is no signal, check the calibrator lamps. Disconnect power and measure the calibration bulbs with an ohmmeter by removing the two connectors on the transmissometer. Measure on P-2 connector of the transmissometer female Pin A to Pin B (zero bulb); if 4 ohms or less, wiring and bulb are not open. Repeat for span bulb, Pin B to Pin C. If both are good, inspect the bulbs by removing (see Calibration Lamp Replacement, Section 4-4), and if bulbs are clean, continue. If bulbs are dark or black, replace bulbs and check calibration marks are correct by initiating a zero/span cycle. If correct, return to normal operation.

7. If signals are still missing, remove rear door on light source and measure the test point TP1 ("COM"). Reference the negative lead of the meter to the power supply test jack labeled GND.

   There should be approx. -1.5 to -2.5v D.C.. If not, replace zener diode D-1 on 100-6002 board.

   If zener voltage is correct, replace I.C. (U-1) on 100-6002.

Remove the jumper from TB1/10 and TB2/8 to return the unit to normal operation. Also, monitor the remote meter for opacity readings in normal operation. If meter reads high, perform the mechanical checks.

3.) <u>Mechanical</u>

At stack location, perform the following:

A.) Dirty Slides. Clean the slides on both the light source and retro housings and check blower filters for excessive dirt buildup.

B.) Target Light Switch. The stack mounted power supply has a target light switch which, in the "on" position (to your left), shuts the main lamp off. This will cause readings to drift high.

C.) Misalignment of Beam on Retroreflector. Check alignment by sighting scope on retro target and adjust if necessary.

D.) Dirt In Stack Mounted Flanges. Remove both housings and clean out flanges with a pipe.

Clean the inner permanent mounted protective window in both the Retro and Transmissometer. Reinstall both housings and note if opacity reading has dropped on remote meter.

F. Inspect the Retro reflector itself by removing the four flathead screws holding the mounting plate to the retro housing. Look for warpage or scratches on the surface. If any is found replace the retro reflector and adjust the Iris over the reflector per clear stack zero procedure page 5-19.

If a clear stack is not available adjust the reading to correlate to a qualified smoke reader, or follow the procedure for off stack calibration page 5-20.

G. If all the above have been done and no problem found, or the flange to flange distance is greater than that which is indicated in the customer information list, the Iris will have to be adjusted per clear stack zero procedure page 5-19.

If a clear stack is not available adjust the reading to correlate to a qualified smoke reader, or follow the procedure for off stack calibration page 5-20.

Fault Diagnostics Codes

The following codes indicate the reason for a fault condition.

1 = RETRO AIR SWITCH.

2 = MEAS AIR SWITCH.

4 = SIGNAL REFERENCE OUT OF TOLERANCE (BAD LAMP?).

8 = RAM APPARENTLY DID NOT SURVIVE A POWER OUTAGE. A RAM REFRESH OPERATION IS NECESSARY.

64 = SOFTWARE ERROR (BAD STACK).

128 = SOFTWARE ERROR (BAD DISPATCH).

Note: Fault numbers 64 and 128 indicate a problem with the computer operation. These faults should occur only under some extreme condition such as a high energy electrical discharge adjacent to the equipment. They will normally clear upon a power restart of the monitor.

Multiple faults are possible. The fault reason shown will be the addition of the fault codes shown above. "HELP" will be displayed on the panel digits (DIGI SWITCH = 00) for the major fault conditions.

MEMORY REFRESH PROCEDURE

A special recovery sequence has been implemented for use in those cases where the protected memory of the micro chassis becomes scrambled due to battery failure, parts replacement, etc. This operation will restore the memory to the standard initialized values.

The standard initialized values will get the system operating again, but for optimum performance, specific installation parameters should be reentered into the memory locations indicated by the system parameter sheet.

The refresh procedure is performed by setting the diagnostic switch to location 99, holding the calibration switch in the zero position, while at the same time holding the modify switch in the decrease position (pinch the two toggle switches together), and then turning the AC power off, then back on again.

The general function inspect/modify method involves setting the diagnostic switch to the proper number, inspecting the current value on the panel digits, and increasing (decreasing) it via the modify command switch. The modify switch, when actuated, will cause the parameter to immediately step to the next logical count. If the switch is held in the actuated position, the value will continue incrementing at approximately a 4Hz rate. The user can then hold the switch until the required setting is achieved. This update rate is one of the user controllable functions (location 56).

CLEAR STACK ZERO PROCEDURE

This procedure should be followed when a clear stack condition is possible.

1. Pull micro chassis out to expose digi-switch.

2. Set locations as follows:

Location	Setting
15	12
17	10
18	16

   Now return digiswitch to location 00. You have set the control unit to read opacity and the stack meter to read transmittance. You are going to adjust the iris on the retro reflector so the stack meter reads 100% transmittance (0% opacity).

3. It is suggested that you use a digital meter in place of the stack meter for greater accuracy.

4. With your digital meter, screwdriver, long nose pliers and clean cloths go to the sensor location.

5. Clean both the transmissometer and retro slides.

6. In the retro reflector weather cover disconnect the stack indicating meter and connect positive lead of your meter to terminal 5 and the minus to 6. Choose a scale which will read .990 to 1.00ma.

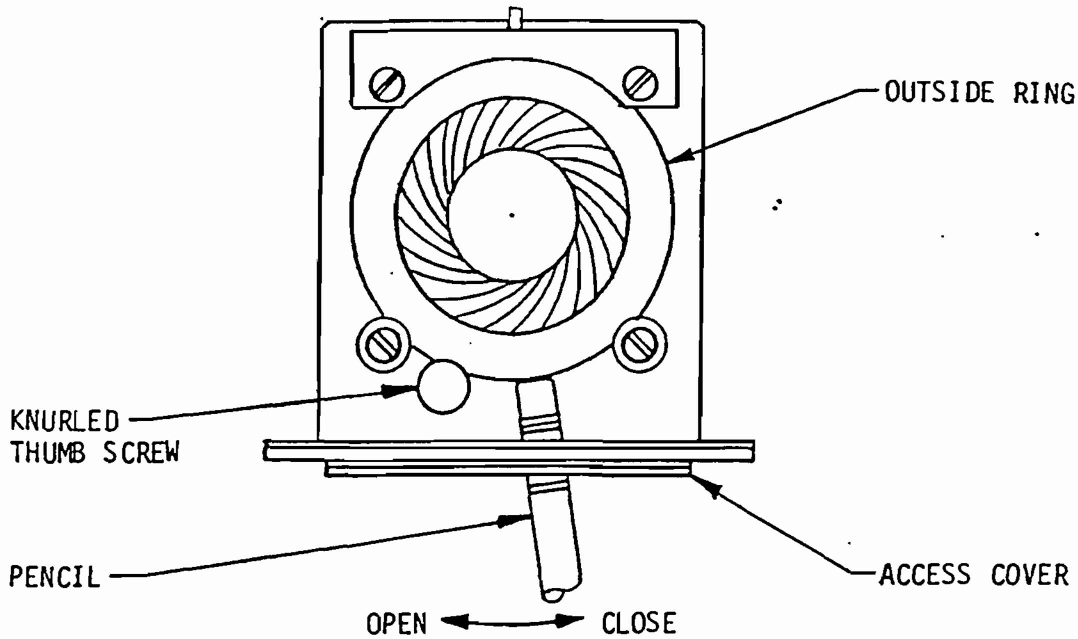
7. Remove iris access plate located just in back of the slide by removing the two (2) 6-32 screws.

8. Unlock iris by loosening the knurled thumbscrew. Use a long nose pliers if to tight to loosen with your fingers (see Figure 1).

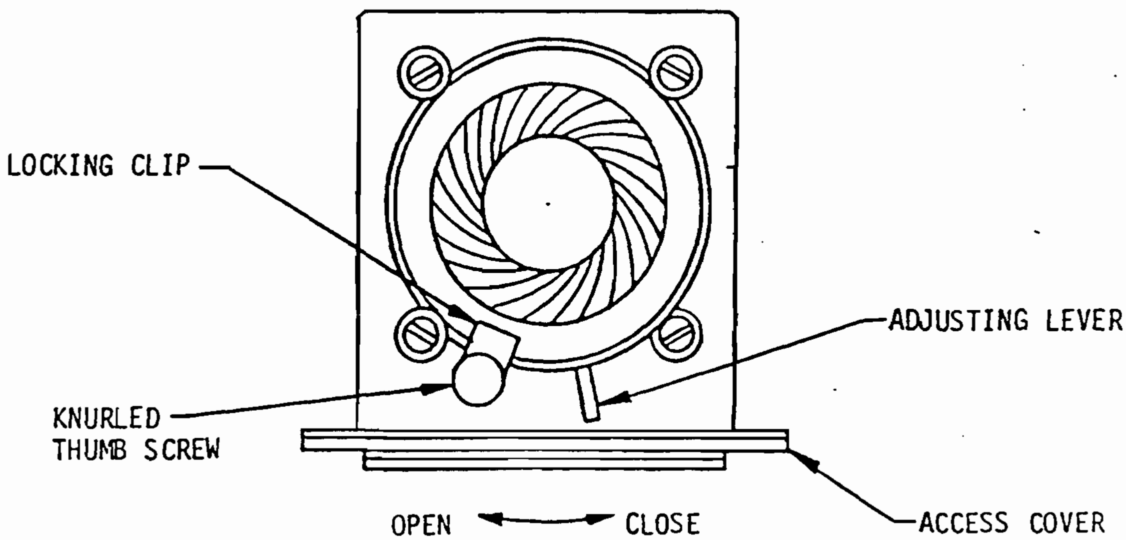
9. Open or close the iris to achieve a reading of .990 to .995ma. The meter may bounce because of residual dust in the stack. It is important not to allow the highest read you observe to go past .995ma. Further than this will drive the opacity readings below zero.

10. When .990 to .995ma has been achieved lock the iris and replace the access plate and return to the control unit.

11. Check opacity reading which should be 0%. Now go to location 17 and 18 and return them to the original values.



PART No. 100-6700



PART No. 100-6700, REV A.

Figure 1

1100M OFF STACK TEST PROCEDURE

Drawings (100-0167 and 100-0166), supplied, will allow you to fabricate a test stand. With this, you can work on the system in a clear and more pleasant environment than at the stack location. The use of the test stand allows accurate adjustment of the iris in a true zero opacity environment. The only other equipment needed is a test cable to connect the control unit to the power supply.

You may purchase test cables and mounting plates from Dynatron. We have supplied drawings for the test stand so you could have them made locally. If you prefer, we could supply the following parts:

Test Cable	Part No. 123-5802	Price - $225.00
Mounting Plates	Part No. 100-0167	Price - $350.00

TRANSMISSOMETER REMOVAL

1. Remove the two quick disconnect cables from the transmissometer.

2. Remove the two screws holding the telescope clamping block located on top of the air purge plenum. The top half will now come free. DO NOT LOOSEN THE SCREWS ON THE BLOCKS THAT SECURE THE TELESCOPE TO THE TRANSCEIVER.

3. Remove the four (4) 1/4-20 nuts at the transmissometer flange and remove the transmissometer and telescope assembly. The lower half of the clamping block, on top of the air purge plenum is now loose and should be stored for use upon reinstallation of the transmissometer.

4. Remove the quick disconnect cable at the power supply that comes from the terminal strip.

5. Unplug the power cord from the bottom of the power supply.

6. Loosen the two slotted screws at the bottom of the power supply and release the 1/4 turn fastener at the top. The power supply can now be lifted off the lower slotted screws.

7. Remove the retroreflector assembly by removing four (4) 1/4-20 hex nuts.

TEST STAND SETUP

Mount the transmissometer and retro on the test stand, connect the power supply to the transmissometer, and use the test cables to connect the control unit to the power supply. You can now apply power.

Place the retro at the exact distance from the transmissometer as it was at the stack (drawing no. 100-0166). The iris access door must be removed so you can adjust and lock the iris in place. Position the retroreflector so the telescope cross hairs line up with the ref. target hole on the retro stand. You may have to move the tripod up or down first. Once this is done, lock up the bolts. The retro should now be in the center of the light beam.

Unlock the iris so you can adjust it. This is done by loosening the knurled thumbscrew (a pair of long nose pliers may be needed if it is tight).

Now, at the control unit, do the following:

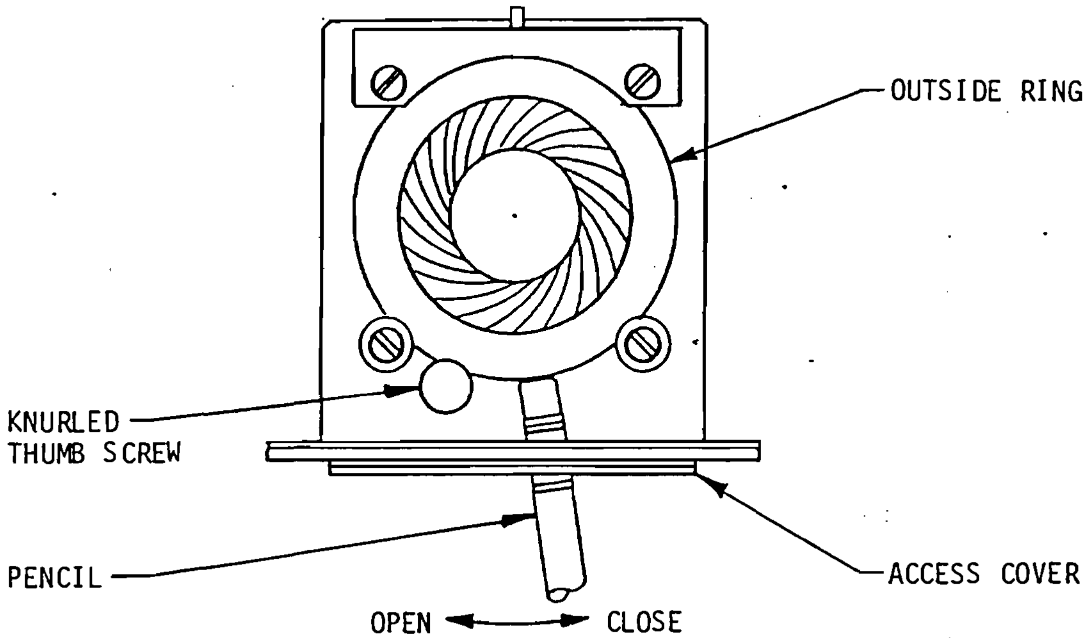
Step	Digi Position	Enter	Purpose
1	15	12	Allow user to change values beyond pos. 15.
2	17	8	Sets unit to display transmittance.
3	00		Unit displays transmittance.

4 See Figure 1. Adjust the iris by rotating the outside ring. One way will cause the display to go up in readings, and moving it the other way will cause it to move down. Adjust it until the unit reads 100 ± 1 count. This corresponds to 100% transmittance (zero opacity).

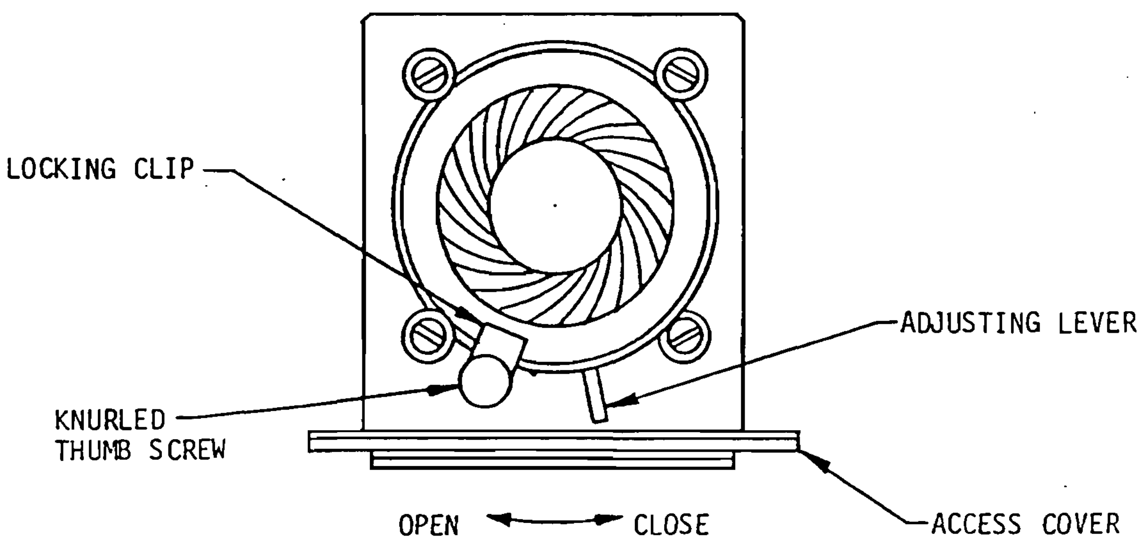
5 Lock the iris in place and return positions 17 and 15 to original value, respectively.

Now, you have zeroed the system and can return it to normal operation, or if desired, perform the calibration test using the three neutral density filters.

RETRO-REFLECTOR ASSEMBLY



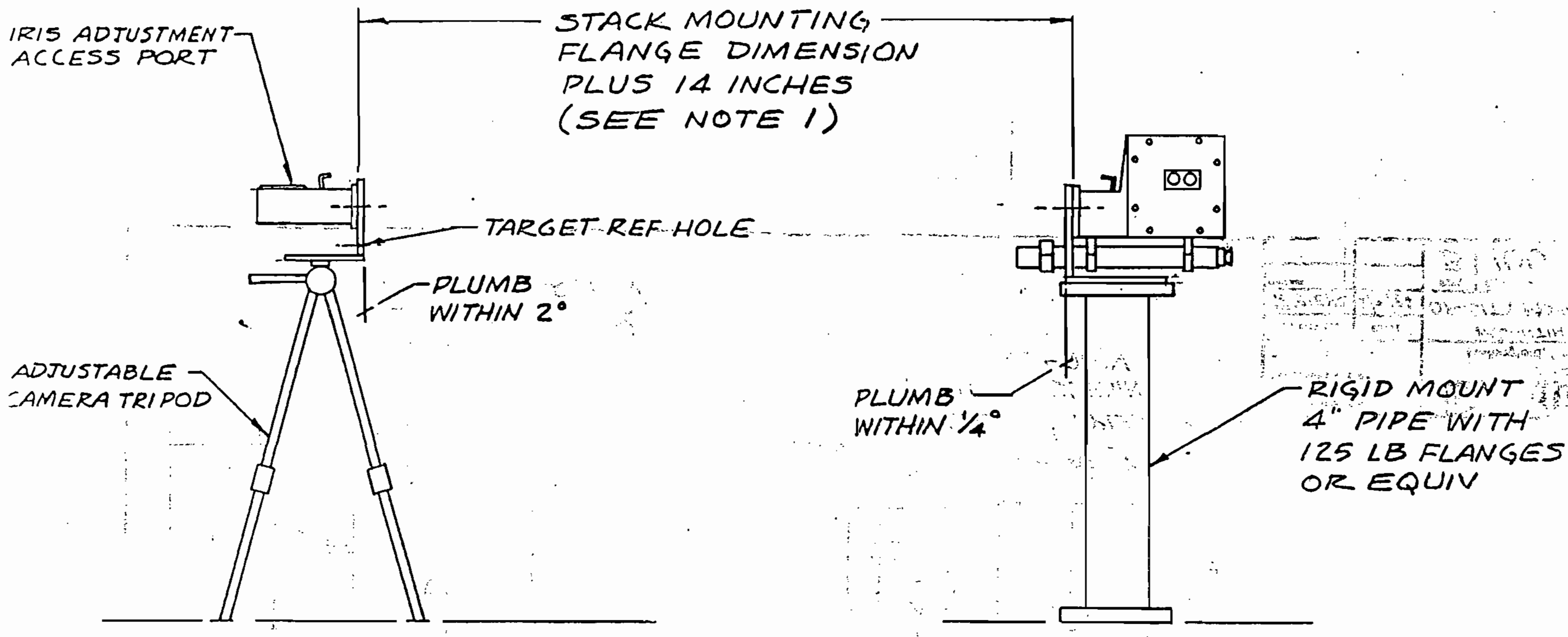
PART No. 100-6700



PART No. 100-6700, REV A.

Figure 1

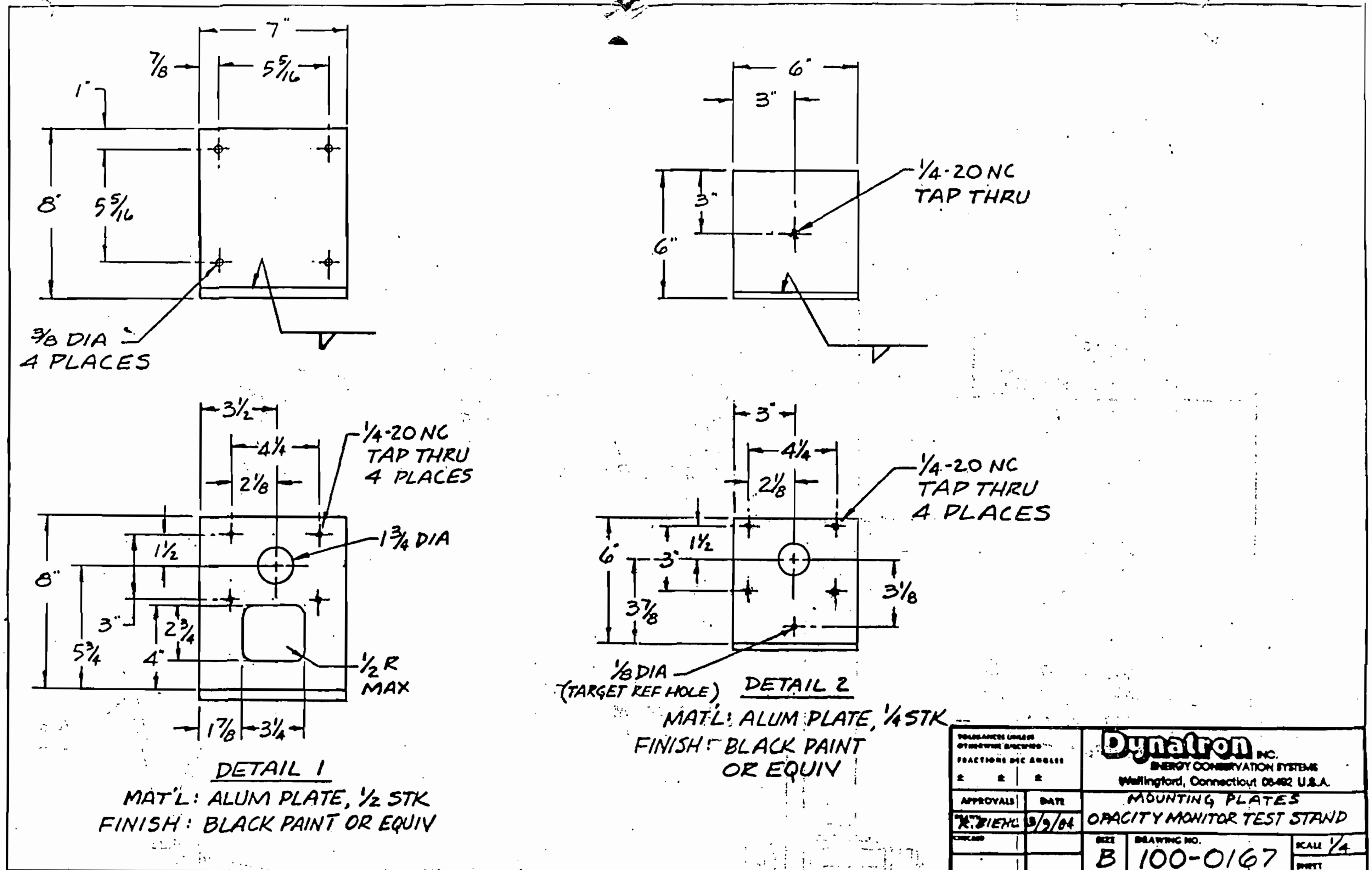
BEST AVAILABLE COPY



NOTE:

1. IF THE OPACITY SYSTEM UTILIZES THERMAL INSULATING BLOCKS BETWEEN THE RETROREFLECTOR AND TRANSMISSOMETER MOUNTING POINTS, INCREASE THIS DIMENSION BY 2 INCHES FOR 1 INCH THICK BLOCKS OR 4 INCHES FOR 2 INCH THICK BLOCKS

TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS DEC ANGLES ± ± ±	Dynatron INC. ENERGY CONSERVATION SYSTEMS Wallingford, Connecticut 06492 U.S.A.
APPROVALS / DATE	OPACITY MONITOR TEST STAND SET-UP
DRAWN R BIEHL 3/9/84	SIZE B DRAWING NO. 100-0166 SCALE 1/8
CHECKED	SHEET


7"
7/8
5 5/16
1"
8"
5 5/16
3/8 DIA
4 PLACES
6"
3"
1/4-20 NC
TAP THRU
3"
6"
3 1/2
4 1/4
2 1/8
1/4-20 NC
TAP THRU
4 PLACES
1 3/4 DIA
8"
1 1/2
3"
2 3/4
5 3/4
4"
1/2 R
MAX
1 7/8
3 1/4
DETAIL 1
MAT'L: ALUM PLATE, 1/2 STK
FINISH: BLACK PAINT OR EQUIV
3"
4 1/4
2 1/8
1/4-20 NC
TAP THRU
4 PLACES
6"
1 1/2
3"
3 1/8
3 7/8
1/8 DIA
(TARGET REF HOLE)
DETAIL 2
MAT'L: ALUM PLATE, 1/4 STK
FINISH: BLACK PAINT
OR EQUIV
Dynatron INC.
ENERGY CONSERVATION SYSTEMS
Wallingford, Connecticut 06492 U.S.A.
APPROVALS
DATE
MOUNTING PLATES
OPACITY MONITOR TEST STAND
K. DIEHL
3/9/84
SIZE
B
DRAWING NO.
100-0167
SCALE 1/4
SHEET

REINSTALLATION PROCEDURE

1. Before reinstalling the transmissometer, it is important to verify that there is no buildup of fly ash in the 6" pipe nipples. Any obstruction of the light beam will cause elevated opacity readings. Viewing the pipe with a flashlight may determine if obstruction has occurred.

2. Scrape the bottom of the 6" pipe nipple with an offset scraper that will fit through the air purge plenum hole to insure that no buildup occurs.

3. Reinstall the transmissometer as follows:

   A. Reinstall the transceiver and air purge clamping block. Replace and tighten the four (4) 1/4-20 nuts and the two (2) 10-32 air purge block screws. This block is important, because it provides purge air to the telescope.

   B. Reinstall the power supply assembly and tighten the two screws and the 1/4 turn fastener.

   C. Reconnect the cables:

      a.) The cable from the terminal strip to the power supply.

      b.) The cables (2) from the power supply to the transceiver (they are designed to connect only one way).

      c.) Plug in the 110v power cord into the stack supply (be sure to turn off the target light).

   D. Verify alignment. Illuminate the target light and verify that the telescope cross hairs are aligned with the target (be sure to turn off target light when finished).

   E. Reinstall the retroreflector. Be sure that the iris is locked in place, the access door is replaced, and all screws tightened.

The transmissometer is now accurately zeroed and calibrated.